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EUROPEAN SCIENTIFIC NOTES. VOLUME 32, NUMBER 11,(U)
NOV 78 A W PRYCE, V S HEWITSON

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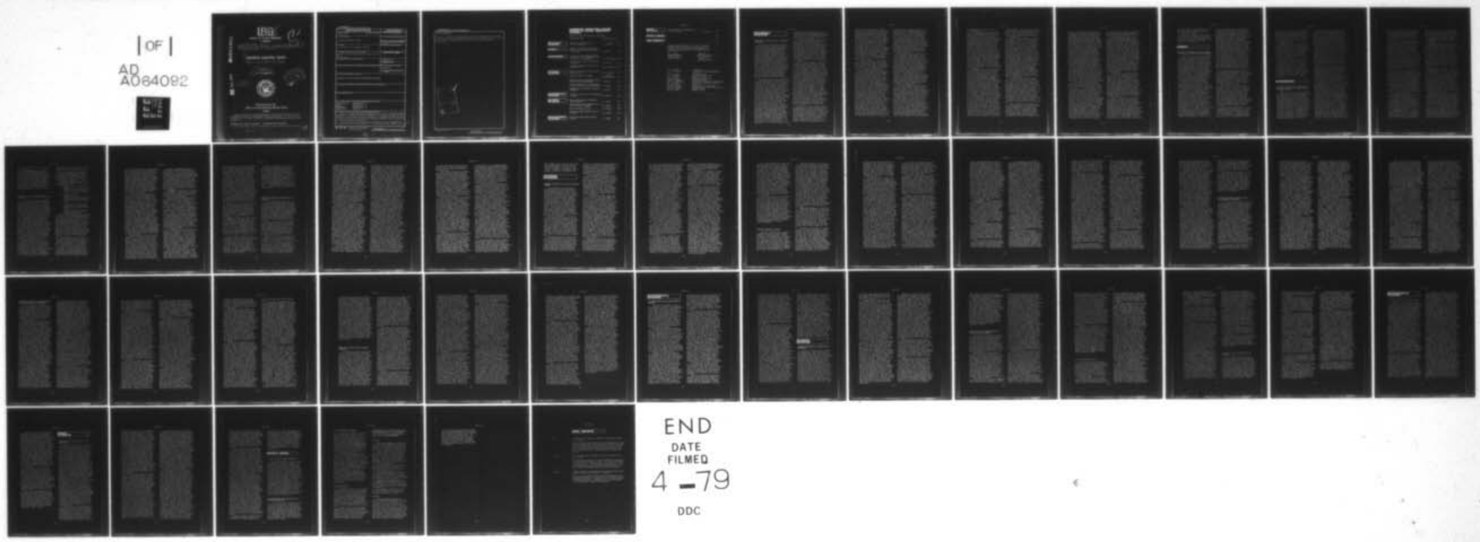

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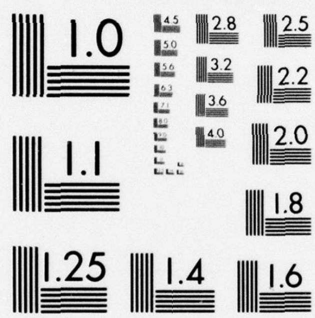

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(10) Aubrey W. Pryce Victoria S. Hewitson

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EUROPEAN SCIENTIFIC NOTES.

Volume 32, Number 11,

(14) ESN-32-11

(11) 30 November 1978

(12) 46p.

Distributed by the
Office of Naval Research Branch Office,
London

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ESN 32-11	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly publication, November
		6. PERFORMING ORG. REPORT NUMBER ESN 32-11
7. AUTHOR(s) A.W. PRYCE & V.S. HEWITSON, EDITORS		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research Branch Office London Box 39 FPO New York		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 30 November 1978
		13. NUMBER OF PAGES 40
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

BIOLOGICAL SCI	MATHEMATICAL SCI
ENERGY	PHYSICAL SCI
ENGINEERING	PSYCHOLOGICAL SCI
MATERIAL SCI	SPACE SCI

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Aubrey W. Pryce and Victoria S. Hewitson

30 November 1978 | Volume 32, No. 11

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

Herbert Solomon
HERBERT SOLOMON
Chief Scientist

P.F. Gibber
P.F. GIBBER
Captain, USN
Commanding Officer

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BIOLOGICAL SCIENCES

URSI AND BIO-RADIO SCIENCE: A HELSINKI SYMPOSIUM

Returning from Helsinki after listening to all but 3 of the 60 papers and looking at the 20-odd poster exhibits, that together made up the Open Symposium on the Biological Effects of Electromagnetic Waves during the recent XIX General Assembly of the International Union of Radio Science (URSI), I noticed a report in the London Evening Standard headed: "Eye Damage Fear on Micro Ovens." The article was prompted by an unique New York lawsuit claiming microwave oven leakage as the cause of cataracts in the two plaintiffs. The reporter went on to mention that although there is a microwave oven boom in cafes and restaurants in London, health authorities have no equipment for measuring radiation leakage. In any case, he noted, safety standards are controversial, with permissible levels of exposure differing about one-thousandfold between the USSR and the West.

The Russians are being too cautious, it is sometimes said; but perhaps we in the West have been too lax. Of British complacency there can be little doubt, if failure to take part in the URSI Symposium is a fair sign. Not a single paper came from the United Kingdom. By the same token, the problem is being taken very seriously in the US and Canada, with 59 communications out of 83 (including posters), against only 13 from the USSR, Poland, and Czechoslovakia, and 11 from West Germany, Finland, Sweden, Denmark, France, and Italy. So it was very much an American show, and if any step was taken toward the desired East-West *rapprochement*, it was taken behind the scenes. While many of the US reports dealt with painstaking (and often fruitless) efforts to repeat results on microwave hazards generated in the USSR and satellite countries, the small Russian team offered little that was new. Its members were handicapped by the dominance of the English language and the American addiction to homely colloquialisms beyond the reach of the foreigner trying to recall his high school English. To this extent the Symposium was a disappointment. On the other hand, it was clear that the US organizations most closely concerned have become more alive to the dangers of the nonionizing pollutant, even if the Russians should be shown to have overreacted.

It is not, of course, simply a matter of leaky microwave ovens. As C. Romero-Sierra (Queen's University, Ontario) said, "the electromagnetic environment will soon be a dominating one." W.R. Adey (V.A. Hospital, Loma Linda, CA), speaking for D.R. Justesen (V.A. Hospital, Kansas City, MO) referred to "the constant rain of microwave energy" and the urgent need for proper standards in anticipation of the large increase in pollution that will occur if tidal turbines and stratospheric solar power stations are developed. Can we reconcile future benefits with the accompanying dangers?

It is also not simply a matter of avoiding or defusing danger. The biological effects of nonionizing fields are not studied solely for the benefit of the environmental hygienist. There are possibilities of application in medicine, in agronomy, in theoretical cell biology, among the many subjects touched on in the Symposium and ably summarized by Romero-Sierra in a "State-of-the Art" talk. This diversity betokens a field profusely vegetated but in need of a little judicious weeding. Perhaps this will be accomplished by a new organization infelicitously christened The Bio-Electromagnetics Society. I am sure its founders do not intend to corral the word "electromagnetic" for their own limited uses. Equally, I cannot believe that they would be so immodest as to engulf the established fields of radiobiology and photobiology, but they are vulnerable to such misinterpretations. Perhaps in reality the banner matters less than what goes on beneath it, and among the Society's first achievements, I understand, will be publication *in extenso* of the proceedings of the Helsinki Symposium and organization of the next meeting, to be held near Paris in 1979.

In the rest of this article and a forthcoming one I shall follow a frankly personal bias on the principle that scientific attractiveness, like beauty, lies in the eye of the beholder. It seems to me that there are two widely separated, but ultimately converging, areas especially worthy of current attention. The first is the empirical identification of the inimical effects on man of chronic exposure to nonionizing fields

too weak to be sensed or to impose a significant thermal burden. The second is the search for comparatively simple systems which demonstrably suffer the immediate consequences of the primary biophysical events that underlie these harmful phenomena. From this standpoint the more or less acute results of thermal loading by microwaves, even though not yet fully catalogued or understood are of less interest. I do not mean to suggest that the distinction can be sharply drawn. There may well be a twilight zone in which local resonances or standing waves, giving rise to "hot spots," produce effects quite different from those observed when extra heat is supplied by other means. The audible click produced by pulsed microwaves is a good example still under investigation (J.C. Lin *et al.*, Wayne State Univ., Detroit, MI).

I shall mention here some of the Symposium papers dealing with the effects of weak radio waves and extremely low frequency (ELF) fields on man and other animals, reserving the discussion of work on partial systems for an article in a later issue of *ESN*.

Establishing long-range effects of radio waves on people occupationally exposed is by no means easy, for many of the symptoms are subjective. The etiology of clinical signs may be obscure and the range of objective biochemical and physiological measurements available may be very limited, for obvious reasons. The problem is still more difficult for the population at large in outdoor city environments where the levels of radiation are often still quite low but subject to wide variation and are high in the vicinity of radio, television, and radar transmitters. Naturally much reliance has been placed on experiments with animals but, as M.G. Shandala (KNIIOKG, Kiev, USSR) pointed out, this introduces the new problem of extrapolation to man. There is also a difference of approach between East and West which may account for some of the disparate conclusions drawn. We in the West are dedicated to the conventional concepts of laboratory experimentation. The Russians, on the other hand, embrace what Adey, speaking for Justesen, called "the admirable construct of ecological validity" involving real-world modeling and prolonged exposure to multi-path fields, with the attendant difficulty of determining whether observed changes are due to the radiation or to a combination of incidental stresses. He might have said that incidental stresses are almost as difficult to avoid in the laboratory, and just as insidious. V. Riley and D.H. Spackman (Pacific NW Res. Foundation, Seattle, WA) showed that anxiety stresses may produce some of the effects that have been ascribed to radio waves, and M.F. Gillis and W.T. Kaune (Battelle Pacific NW Labs., Richland, WA) described experiments from the results of which one might suspect that animals "know" when they are placed in a 60-Hz field because of tactile stimuli caused by vibration of hairs.

The Russian approach was described also by Shandala. The emphasis, he said, should be on detection of changes in the standardized fuctional state of the organism rather than on the possible intrusion of pathological events. Sub-threshold fields cause changes which either remain within the normal limits of variation or which can be brought back within those limits by adaptation. However, Shandala claims that pathological changes can be produced at power density levels which are still far below the accepted US threshold of 10 mW/cm^2: for example, at 50 μW/cm^2 UHF (0.3 - 3.0 GHz) the "immune response" is depressed and at 50-500 μW/cm^2 tissue proteins become immunologically foreign. Again, between 30 and 50 μW/cm^2 chromosomal aberrations occur, haploid cells increase, and fetal abnormalities are produced in pregnant rats.

Little was added to the many existing reports on human beings accidentally or intentionally subjected to insensible fields. B. Servantie (Hôpital Ste.-Anne, Toulon Naval, France) reported loss of weight, neurovegetative ailments, blood hypercoagulability, and pituitary insufficiency in a person after exposure for three years to "*champs diverses*" at about 1 mW/cm^2. Adey (for Justesen) mentioned that the "neurasthenic syndrome" characteristic of prolonged exposure to weak fields could be produced by an acute rise of brain temperature of about 1°C. The analogy contributes little to the question of chronic effects. W.D. Masterson (Univ. of Texas at Dallas, TX) found that small nonhomogeneous increases in the geomagnetic field modified the functional balance between right and left brain, while weak uniform fields caused changes in skin temperature

and conductivity, probably by way of the hypothalamus.

The reported work on animals covered a wide range of zoological types, ambient field characteristics and recorded data, in such an inevitably spotty manner as to conjure up an image of a clear sky viewed soon after dusk. A balanced summary would be difficult. My own bias is toward behavioral and neurophysiological approaches on the supposition that the central nervous system is sensitive to electric and magnetic disturbances, fortified by the fact that it is here that correlations between changes induced by microwaves and by ELF fields are most likely to be encountered. At the other end of my value scale are those measurements of chemical, hematological, and immunological parameters that appear to have been made because the necessary techniques are there, like Everest, and not because there has been good reason to suppose that anything of interest might be discovered. But then, science would lose its charm if the unexpected never happened.

The Russian contributions included an interesting survey by J. Kholodov (USSR, affiliation not given) of the effects of magnetic fields and microwaves on the locomotor activities of fish, birds, and mammals. Typical results included large dose-dependent decrease of activity in birds exposed to power densities from 2 to 1000 $\mu W/cm^2$. Evaluation of this work must await the appearance of Kholodov's book, in preparation. Performance data on wild mallard ducklings exposed to an amplitude-modulated 450-MHz field at 1 mW/cm^2 were given in the abstract by the absent R.G. Medici and G. Lesser (Univ. of California, Brain Research Institute, Los Angeles). Stimulation was greater at a modulation frequency of 16 Hz than at 3 Hz. Shandala *et al.*, less adventurous than Kholodov, confined themselves to rats, finding that during regular exposure for a month to power densities of 500 $\mu W/cm^2$ at 2375 MHz exploratory activity was suppressed. Upon removal of the field overcompensated recovery occurred, with increased activity that persisted for 5 months. The confidence limits were large. The remaining Russian paper came from I.P. Loss *et al.* (KNIIOKG, Kiev), who found notable differences in various behavioral and biochemical factors among rats exposed for 20 hours daily to microwaves at 60 $\mu W/cm^2$, to intermittent simulated turbojet screw noise at 80 dB, to both, or kept as controls. The combined effects seemed to show some reinforcement rather than strict additivity.

The effects recorded by the Western contributors tended to be zero or unimpressively positive. De Lorge (Naval Aerospace Med. Res. Lab., Pensacola, FL) found the vigilance of rats exposed to 5.62 GHz in 0.5- and 2-μs pulses at 600 Hz to be unaffected until thermal action supervened at a power density around 27 mW/cm^2 and a specific absorption rate (SAR) of about 6 W/kg. On the other hand, M.I. Gage and W.M. Guyer (US EPA, Res. Triangle Park, NC) found that the response rate of rats to a food stimulus decreased in a constant field of 2450 MHz, while J.C. Monahan and W.W. Henton (Bur. Radiol. Health, FDA, Rockville, MD) found that rats moved out of a 2450-MHz field when free to do so. Thermal effects may have been responsible. I was interested in the finding from both laboratories that the animals' sensitivity to the UHF field became greater at higher ambient temperatures. The device of providing a suitably controlled supplementary stress in order more convincingly to detect radiation effects would be worth adopting in many kinds of experiment.

In the very low-frequency range rats have been shown by R.D. Phillips *et al.* (Battelle Pacific NW Labs., Richland, WA) to have definite preferences for being in, or out of, a 60-Hz field, depending on field strength (25-100 kV/m) and other factors. However, subtle pleasant or disagreeable field-associated perceptions have not been excluded. D.M. Weissfeld, speaking for D.M. Koltum, himself, and Y. JoSeto (Tulane U., New Orleans, LA) said that the electroencephalograms and the visually evoked potentials in rats conceived and raised in a vertical 60-Hz field, 20 kV/m, differ from those of the controls, tending to become normal when the field is turned off.

Other microwave studies dealt variously with mutagenesis, skeletal muscle, and egg production. E. Berman and H. Carter (EPA, Res. Triangle Park, NC) found no evidence for dominant lethal mutations in rats exposed for various periods pre- and post-partum to 425- or 2450-MHz fields, and no change of reproductive efficiency in the male off-

spring. The power densities were near or within the frankly "thermal" range, 5-28 mW/cm^2. Perhaps it should not be assumed that the same results would be obtained at lower power densities, more prolonged exposures, or different frequencies, but a comprehensive screening program would be formidable. Rather high fields, 10 mW/cm^2, were also used by A. Portela *et al.* (Inst. de Investigaciones Biofisicas, Jafatura III, Buenos Aires, Argentina; Brown Univ.; Nat. Inst. of Gen. Med. Sciences, US) who determined the electrophysiological properties of sartorius nerve-muscle preparations from frogs that had been subjected for long periods to 2.88-GHz fields in 0.67-μs pulses at 900 Hz. The data, analyzed with the aid of a new method of integrating the Hodgkin-Huxley equations, showed no differences in the various membrane excitation parameters from those of preparations from control animals and no differences in their temperature coefficients. Thirdly, J.A. Tanner (Nat. Res. Council of Canada, Ottawa) found that hens exposed continuously to 7.06 GHz at 0.18-360 μW/cm^2 produced more eggs than those not so treated but suffered deterioriating health with many deaths from avian leucosis and tumors of the central nervous system. One wonders whether the two effects were interrelated and whether either was really caused by SHF radiation.

Two attempts to check alleged changes in the permeability of the blood-brain barrier (BBB) during microwave irradiation were described. Spackman, Riley *et al.* (given by Riley) used 4 substances as chemical tracers. Two (fluorescein and galactosamine) penetrate the normal BBB to some extent while the others (homocystine and isoglutamine) do not. Irradiation of mice at 918 MHz, continuous or pulsed at 10 μs and 100 Hz, at quite high power densities (2.5-132 mW/cm^2) produced no demonstrable change: the first 2 substances entered the brain at the normal rate while the second 2 were always excluded. Studying the same question with dogs, and using as tracer plasma albumin tagged with 131-iodine, B. Chang *et al.* (Duke Univ. Med. Center, Durham, NC) sampled the cerebrospinal fluid in the cisterna magna after 20 minute exposures to 1.0 GHz at several power levels between 2 and 200 mW/cm^2. Except for 4 dogs out of 11 at a single power density (30 mW/cm^2) the results were negative. I am unenthusiastic about the conclusion from the occasional atypical result that the minority four exhibited "a microwave power window effect."

The hematological study reported by H.A. Ragan and R.D. Phillips also suffered from the irreproducibility of what were considered to be statistically significant effects. One is tempted to ask, in connection with this and the preceding comment, whether it is not an abuse of statistics to separate the results of successive identical experiments into those that appear to be mathematically "significant" and those that do not. But it is no doubt legitimate to wonder whether uncharacteristically wide variability may mean that something interesting, and perhaps worth pinning down, is indeed going on. In any event, these careful experiments did not succeed in demonstrating convincingly any consistent change in the hematological properties, serum chemistry, and bone marrow hematopoietic plaque-forming titer occasioned by prolonged exposure of mice to 2450-MHz continuous field or 2800 MHz pulsed at 2-3 μs, 100 Hz and 5-10 mW/cm^2.

A preliminary observation that may prove to be very interesting was mentioned almost in passing by C-K. Chou (Chou *et al.*, Univ. of Washington, Seattle, WA) while describing an elaborate study of the effect of continuous and pulsed 2450-MHz fields on rabbits at 1.5 mW/cm^2 administered for 2 hours daily for 3 months. No changes in electroencephalogram, body weight, blood chemistry, and hematology were found and no histophathology was detected. Yet the extremely sensitive dose-dependent hyperthermia produced by apomorphine, characterized by hyperactivity and pupillary dilation, seemed to be modified by the microwaves.

There is a long way to go before the effects of weak fields on man can be considered firmly established and understood, but there are now enough positive results amid a sea of negatives to guide us in choosing the lines of further research. It is, however, unfortunate that most of the work described at Helsinki, even that emanating from the East, has been done at power densities too high for the suspicion of thermal mechanisms to be confidently ruled out. It is as if the investigators want to make the best o both worlds. The attempt may satisfy the sources of largesse,

with their thirst for publishable proof that something is happening, but in the long run the result can only be to obscure the issue.

As for the properties, as revealed in Helsinki, of isolated cells, organelles, and other biological sub-systems as sensors of nonionizing fields, these will be discussed in a subsequent article. (J.B. Bateman)

ENERGY

MAGNETIC CONFINEMENT AT THE MAX-PLANCK-INSTITUTE OF PLASMA PHYSICS IN GARCHING

On a recent visit to the Max-Planck-Institute of Plasma Physics in Garching I had the privilege of speaking with Prof. Arnulf Schlüter about their program in thermonuclear research in general and the magnetic confinement program in particular. Ever since the development of the TOKOMAK in the USSR, most of the leading plasma physics laboratories throughout the world have been exploring this device as the most promising avenue for the possible production of fusion energy. At the Max-Planck-Institute there is such a program in progress along with continuing investigation of the stellarator device that was first proposed in Princeton and is now almost abandoned elsewhere. The TOKOMAK is a containment scheme for a hot plasma in which the confinement configuration is a torus. The TOKOMAK currently being built at Garching is called the ASDEX, which is an acronym for axisymmetric diverter experiment. The purpose of the experiment is to explore means of diverting plasma and impurities from the main toroidal confinement configuration so that the plasma can be analyzed and the impurities removed. ASDEX's torus has a major radius of 1.64 m and a minor radius of 0.40 m. The constant azimuthal field supplied by the principal magnetic windings is 28 kgauss, the plasma current induced in the configuration is 500 kA, and the discharge time is of the order of 1 sec. There are additional diverter coils inside the casing of the ASDEX machine which are intended to divert plasma out of the principal torus configuration. TOKOMAK differs from previous machines in that the plasma is not pinched in order to heat it to high temperatures, but rather the heating proceeds by ohmic dissipation of energy in the plasma. Dr. Helmut Niedermeyer led me around the laboratory and showed me the ASDEX in process of construction. Suffice to say that though the ideas are simple, the execution is extremely complicated. Niedermeyer explained that besides ohmic heating there will also be a facility for heating the plasma through the injection of neutral atoms into the plasma. These atoms will have energies of 50 keV per atom. In addition to neutral atoms, it is proposed to inject large molecules of hydrogen in which the atoms are bound by Van der Waals' forces. These large molecules or droplets each consisting of a few thousand atoms of hydrogen will have energies of 500 eV per atom during injection. Additional injection of pellets of frozen hydrogen are proposed for refueling the machine. It is important that these pellets be injected at the proper velocity so that they neither penetrate through the toroidal confinement configuration completely nor are vaporized and ionized at the outside of it.

Dr. Dieter Meisel conducted me around an earlier TOKOMAK at the laboratory called the pulsorator. This TOKOMAK, which copied the original Russian configuration faithfully, has a discharge time of approximately 120 msec and is used principally for diagnostic studies. The pulsorator also has stellarator windings to provide very small asymmetric applied magnetic fields.

The stellarator, which is still being used actively at the Max-Planck-Institute, is not being run as initially intended. There is very little magnetic pinching, and the stellaratory windings introduce an asymmetric component to the confinement magnetic field of the order of 2% of the rotationally symmetric or toroidal field. The discharge time in the stellarator is 400 msec and the confinement time is about 10 msec. The effective minor radius of the machine is 11 cm, and the aspect ratio of the toroidal confinement zone is about 20. The maximum field strength is about 40 kgauss.

In the TOKOMAK experiments the magnetohydrodynamic (MHD) stability of the confinement is being studied. The most serious instability or tearing mode is that which produces an elliptical minor cross section to the confinement configuration, and it is found that this in-

stability is stabilized by a stellarator field. Once the magnetically confined plasma is stabilized against this elliptical mode, the higher modes of instability can be identified and studied. At this point it seems that a small stellarator field improves the confinement time by a factor of 2 to 5 over a pure TOKOMAK field.

Schlüter has been carrying on a theoretical investigation of the MHD stability of confinement configurations. In this regard he has developed programs and codes for numerical experiments on plasma instability, and the comparison of the experimental results with his theory is truly remarkable: Results that he has obtained theoretically are in direct coincidence with those obtained in the laboratory.

Although we must continue to hope for the success of the Max-Planck-Institute and similar research establishments in providing us with a new energy source, it would be extremely foolhardy for us to place our full dependence on this as a solution to our energy problems. Rather, we must also concentrate on available technology and perhaps a change in life styles to conserve as much depletable energy as possible at this point. (Martin Lessen)

ENGINEERING

INSTITUTE OF RADIOENGINEERING AND ELECTRONICS OF THE ACADEMY OF SCIENCES OF THE USSR (MOSCOW)

During a recent visit to the USSR as a member of an Institute of Electrical and Electronic Engineers delegation participating in a scientific and technical exchange program with the A.S. Popov Scientific-Technical Association for Radio Technology and Electrocommunications (The Popov Society), I visited a number of educational and research institutes working in the field of radio engineering and related fields. The Institute of Radio Engineering and Electronics, one of these, employs 422 people and is housed in serviceable but seemingly old quarters situated quite close to Red Square. Entry to the building is through a security control gate not unlike typical industrial/military secure areas in the US.

Our host at this particular institute was Prof. Yuri V. Gulyaev, the Deputy Director and Head of the laboratory. Gulyaev is young (fortyish), impressive, speaks excellent English, is well acquainted in the Western World, and has a most engaging personality. He discussed two main themes of the laboratory's activity: electromagnetic wave propagation and electronic devices. In the former area interest extends from long waves through the optical region of the spectrum. Attention is devoted to atmospheric and space propagation, active and passive studies of the Earth, planetary atmospheres, and radar studies of planets. In the area of optical fibers attention is focused on graded quartz fibers with losses less than 2 dB/km and on 100-μm-diam. hollow, gas-filled fibers. Data rates of the order of 50 Mbit/sec have been achieved with light emitting diodes (LED), and of the order of 500 Mbit/sec with laser sources.

In the area of electronic devices emphasis is on the generation, detection, amplification, and signal processing of electromagnetic waves in the MHz to GHz regions. The effort includes development of surface acoustic wave devices, and Gulyaev noted that pulse compressions up to 10^4 have been achieved. He also pointed out that, "Surface acoustic wave device production amounted to $300 million in the US last year." The figure appears to me to be grossly high, but then maybe this merely reflects an argument he uses to justify his budget to his management. (A little such amplification in both the Soviet and US parts of this loop might well enhance research budgets in both places, but it isn't likely to attenuate the arms race!) The Institute is also studying sensitive detectors including Josephson junctions and SQUID configurations of Josephson junctions. Noise equivalent powers of 10^{-13} to 10^{-14} W/$\sqrt{Hz}$ were mentioned along with an estimate that 10^{-20} might be attainable in the superheterodyne configuration. Also with regard to detectors, Gulyaev commented that it is possible to make a magnetic-field-tunable maser using the quantum size effect (QSE). QSEs occur when one (or more) specimen dimension becomes comparable to the charge carrier (De Broglie) wavelength. Such effects are expected to play important roles as electronic devices are further microminiaturized. Although the QSE was "discov-

ered" at the Institute of Radioengineering and Electronics, that Institute is just now starting to undertake investigations of inversion layer QSEs in semiconductors, an area that has been actively pursued for many years in the US.

This topic triggered an interesting discussion on the formal meaning of the word "discovery" in the USSR. Gulyaev indicated that discoveries are granted and registered there just as patents are granted and registered. The distinction between discoveries and patents would appear to center on the degree to which the advance is either a new phenomenon or an application of known phenomena. One of Gulyaev's colleagues was quick to point out that discovery number 133 (out of some 150 to date) is the acousto-magneto-electric effect, which was discovered by Gulyaev, who received a monetary prize for his own personal use and of magnitude "sufficient for purchase of an automobile." Another renowned "discovery" is that of the electron-hole liquid in semiconductors.

When queried regarding the funding of the Institute, Gulyaev pointed out that, in addition to the institutional funding base, contract funds are awarded to the Institute for the performance of specific tasks for industry and for development organizations. In spite of this the Institute had recommended in 1964 that industrial organizations should have their own laboratories to short-circuit unwieldy research-development-engineering-production sequences.

Several individual laboratories of the Institute were toured, and the researches are listed below after the name of the investigator (transliterated to the best of my ability):

Vystavkin is investigating the properties of variable-thickness Dayem bridges (Josephson junctions).

Tsarkin is studying electron spin resonance (ESR) and nuclear magnetic resonance (NMR) in superparamagnets. His interests include dynamic nuclear polarization and spin-spin interactions. He uses a microwave pump to increase the paramagnetic susceptibility by as much as a factor of 10^3.

Bascharenov conducts both active and passive remote sensing studies via satellite (0.8-, 1.3-, 3-, 8-cm wavelength) and via aircraft (8 channels from 0.08 to 40 cm). His interests center on the depth and condition of Antarctic ice and on temperature and salinity as they relate to radio brightness. He also conducts studies of agricultural crops and of subsoil character. At 2- and 20-cm wavelengths he determines subsoil water down to 2 m in depth.

Persikov has developed equipment for drawing both solid and hollow optical fibers.

Shakovskoi described investigations underway in Katernikov's laboratory, which participated in the scientific investigations of the first Sputnik (1957) and of the Project Luna Moon landing. Using 40-cm wavelength radar sets in the Crimea, they conduct measurements of Venus and Mars to determine surface roughness, rotation rates, and orbital parameters (to an accuracy of 400-500 m).

Vorshilov conducts satellite experiments to determine the nature of the atmospheres and ionospheres of Mars and Venus. Good correlation with Mariner data was obtained. Plasma was detected in the vicinity of the Moon. Plasma occultation studies of the Sun were conducted.

Yjudski and Iliansov are investigating quantum size effects (QSE) in semimetal single crystals. Bismuth crystals of thickness of the order of 1000 Å are grown epitaxially on mica substrates at 10^{-6} Torr. The size-quantized discrete charge carrier energy levels (subbands) are verified by observation at low temperatures of (a) oscillatory dependence of electrical resistivity on thickness, (b) oscillatory behavior of the second derivative of the electron tunneling current-voltage characteristic, and (c) oscillations in the electrical resistivity versus pressure. This last manifestation of QSE is observed at temperatures as high as 77 K.

Stepanov has developed a nonvolatile semiconductor memory device. It makes use of an Au-doped n-type Si substrate. Depending upon the magnitude and sign of the voltage applied between an ohmic contact and a Schottky barrier contact, a highly conducting filament is either created or destroyed, evidently by melting. Switching is between 1 Ω and 10^6 Ω at 5 to 7 V. Switching time is 10^{-3} to 10^{-6} sec. The device deteriorates after about 10^4 cycles. These are not impressive characteristics as far as memories are concerned, but the device could perhaps find application as a means to disconnect faulty circuits and to connect to functioning replacement circuits in a self-repairing system. De-

tails are published in *Microelectronika* 6, 20 (1977).

Divin and Kogan are developing point contact Josephson junction detectors as wideband radiometers for astronomy studies. Maximum sensitivity is observed at a wavelength of about 2 mm. Noise temperature is about 0.1 K and noise equivalent power is about 10^{-14} W/$\sqrt{Hz}$. An extended report of visits to Electrical and Electronic Engineering Establishments in the USSR will shortly be available as an ONR London Technical Report. (Ted G. Berlincourt, Office of Naval Research, Arlington, VA)

ELECTRONICS IN POLISH AND ROMANIAN UNIVERSITIES

A recent visit to Poland and Romania as a National Academy of Sciences exchange scientist offered the chance of forming some impressions of education in these countries in engineering and particularly electronics. As both countries are Communist, it was expected that the governing structures of their schools would be similar, but each has its own traditions and some background history is therefore important.

Poland dates back to the 970s when Miesko founded the 1st Polish royal line. Partition in the late 18th century brought more than 120 years of servitude before independence in 1919 after WWI. Falling prey to Nazi Germany in 1939, Poland did not become a sovereign state again until 1945. It now has an area of 313,000 km² and a population of 35 million, which is 90% Roman Catholic. There are 106 women to 100 males, and 50% engineers, 64% medical doctors, 80% dentists, and 84% pharmacists are women, and about 1000 hold senior university posts. The oldest university, the Jagiellonian Univ. in Cracow dates back to 1364.

About 400 BC the territory now identified as Romania was inhabited by a Thracian tribe, the Dacians, since which time it has seen many invasions and migrations. Roman colonization from 98-271 AD left its mark, and the Romanians are essentially Latin, although their religion, Romanian Orthodox, is Byzantine in origin. Independence as a monarchy was finally achieved in 1877, and the country was proclaimed a Republic in 1947. It has an area of 237,000 km² and a population of 22 million.

In the European tradition higher technical education in both countries is conducted in independent schools, not in colleges within universities. In Poland these schools are known as Technical Universities and in Romania as Polytechnic Institutes.

Engineering degrees offered are similar in the two countries but not the same and include:

(1) Poland—Mgr inż. (Magister inżynier)
Romania—Ing (Diploma Engineer)
requiring a thesis, and equivalent to a Master's degree

(2) Poland—Dr. inż.
Romania—Dr. ing.
requiring a defended doctoral dissertation based on original research among other requirements

(3) Poland—Dr. hab. inż (Dõktor Habilitowany of Engineering)
Romania—D.Sc. (Doctor of Science)
a doctoral degree similar to the British DSc and a step higher than the PhD.

There are four faculty ranks in both countries corresponding to the Professor, Associate Professor, Assistant Professor, and Instructor, the senior level in Poland being further divided into two grades namely Ordinary (Prof. zw.) and Extraordinary (Prof. nadzw.) the former being the higher. Ceilings on the number of Profs. and Assoc. Profs. on a faculty are 12% in Poland and 16% in Romania. Salaries are low by US standards, but contract research permits some augmentation, and in Communist countries there are no taxes and the government provides education, health care, and pension.

In Poland, there is a technical university in each large city, but a separate Electronics Faculty exists only in Warsaw (Waszawa), Danzig (Gdańsk), and Breslau (Wroclaw). The Technical Univ. at Warsaw with 23,000 students is the largest of all the universities in Poland. Its Electronics Faculty is divided into five Institutes; Basic Electronics, Automatic Control, Radioelectronics, Electron Technology, Telecommunications, and Computer Science, and in recent years the annual output

of this Faculty alone has averaged about 110 Inż's, 240 Mgr. inż's, and 26 Dr. inż's. The Institute of Basic Electronics has a teaching staff of about 95 with 4 Professors, 5 Docents and 20 Adjuncts. Currently it has 12 research groups working on synthesis of active systems, topological methods of linear network analysis and design, nonlinear network theory, analog electronic circuits, pulse and digital electronics, biocybernetics, microwave and solid-state electronics, optoelectronics, measurement of nonelectrical quantities, digital measurement systems, parameter measurements of nonlinear networks, and reliability problems.

In Danzig, as in Warsaw, most of the city's historical buildings and landmarks have been painstakingly rebuilt and restored since WWII. Here electronics is one of 9 faculties in the Technical University. It has about 1,000 students and and consists of 3 Institutes; Telecommunications, Cybernetics, and Electronic Technology. Telecommunications has a total staff of 200, and its teaching duties are distributed among 6 Chairs: in microwaves, electroacoustics, radio communication, wire communication, theory of electronic circuits, and information system theory. Prof. dr. hab. inż. Krzysztof Grabowski's microwave laboratories have research projects in passive MIC (microwave integrated circuit) devices, automation of microwave measurements, receiver-noise elimination, frequency stabilization of X-band radio link, and wave propagation in anisotropic media. One staff member is interested in the problem of detecting underground running water by radiation measurements and apparently can detect radiation near 1.42 GHz over underground running water at some locations.

Breslau was not visited, but the electronics institutes at the Technical Universities of Lódź and Cracow were. Lódź, an industrial city, has a population of 800,000 and is the second largest city of Poland, with many textile factories. Here there is no separate Electronics Faculty, but there is a 4-year old Institute of Electronics with a teaching staff of 46. This Institute has been involved in instrumentation work, as well as in the design and fabrication of 5-kW, 20-25-kHz ultrasonic generators and of testing apparatus for TTL circuits. Some work on microprocessors and computer-aided design is also being carried out.

Cracow, a prosperous city of 700,000 was the seat of the Polish monarchy from the 11th to the end of the 16th century. It is rich in historical, cultural, and intellectual heritage, and by some miracle escaped the havoc of WWII. It's Technical Univ. is 32 years old with 6 faculties, but it does not have a separate Electronics one. The Institute of Electronics, established in 1974, is a part of the Faculty of Transport and has a teaching staff of 37 with a main interest in electric machines, automatic control, and digital and analog circuit modules.

In Romania there are four polytechnic institutes: at Bucharest, Timişoara, Cluj, and Jassy, while electrical engineering is also taught at the universities in Brasov and Craiova.

The Polytechnic Institute of Bucharest has about 25,000 students and is the largest university in Romania (cf. Warsaw). Its original buildings are rather old, but a much more spacious campus with impressive new structures is now being built in another section of the city. The Department of Electronics is a part of the Electrical Engineering Faculty and has a teaching staff of 3 Profs., 4 Assoc. Profs., 4 Asst. Profs., and 10 Instructors who have published a large number of textbooks in Romanian, a casual examination of which indicates a coverage and treatment comparable to those in English at the same level. Ongoing research projects in the microwave area include synthesis and optimization of antenna arrays, frequency-scanned X-band waveguide slot arrays, digital radar speed measurement, high-power magnetrons and circulators.

At Timişoara (the first town in Europe to have electric street lighting) there are 5 faculties, in electrical, mechanical, chemical, civil, and agricultural engineering. The Electrical Engineering Faculty with 2,000 students comprises 4 departments: electrotechniques (electric machines), energetics (power transmission and distribution), applied electronics and telecommunication, and computers. The Computer Department is particularly active with the work divided into hardware, software, automata, and process control.

Cluj with a population of 300,000 is the second largest city (now challenged by Timisoara) in Romania. The Polytechnic Institute, founded in 1948, has 3 faculties, in electrical, mechanical, and civil engineering. Electrical Engineering with 800 students is divided

into 3 departments: electrotechniques, automation and computers, and electronics. Active work is being conducted on incremental-motion control systems and devices, measurement of nonelectrical quantities, and a software system for computer control and optimization.

Jassy, a city of 250,000 in the northeast, is only 15 km from the Russian border. Engineering education here has the oldest tradition in Romania having begun early in the 19th century. The present 'Gh. Asachi' Polytechnic Institute has 6 faculties and an enrollment of 14,000. The Electrical Engineering Faculty has 4 academic departments: electrical measurements and machines, electronics and computers, power utilization and automation, and electroenergetics. Electronics and Computers has a teaching staff of 18 with synthesis of sequential schemes, electronic systems for industrial control, nonlinear circuits, and software design for special problems as areas of specialization.

Compared to the US, the engineering curricula in Poland and Romania put much more emphasis on the student's ability to design and actually produce some hardware, such as a multipurpose measuring instrument or an automatic control device. This emphasis is important here for an engineer is often required both to design and make a product.

Comments. While the formal courses for the 4½-year Polish Mgr. inż. or 5-year Romanian Ing. degree are comparable to those for an MSEE degree in the US, student academic load is heavy, varying from 34 to 38 contact hours a week, exclusive of workshop activities. Entry to the technical universities is by examination, and an aspiring freshman has only one opportunity a year as the examinations are concurrent. The acceptance ratio is about 2.5 to 1.

By US standards laboratory and library facilities are poor, especially in Romania. There are few sophisticated instruments, even for research, and lack of adequate financial resources (in particular, foreign exchange) is a serious problem. There were no minicomputers or time-sharing computer terminals in sight. At Bucharest, no viewgraph or slide projector was available for a seminar although visual aids were available in Poland.

There is, however, no lack of enthusiasm and dedication on the part of the faculty in either country despite the difficulties and frustrations. Poles and Romanians are frank and generous people, and I was always received cordially and with warmth. I firmly believe that science and technology are independent of national boundaries, races, or political philosophy and that exchange of ideas and practices will encourage knowledge diffusion and progress. A more detailed account of my visit will be available in an ONR London report. (David K. Cheng, Syracuse Univ., Syracuse, NY)

CRYOGENIC TECHNOLOGY—ENGINEERING AND MATERIALS

Two International Conferences on Cryogenics followed each other in rapid succession early in July 1978. The first was the Seventh International Cryogenic Engineering Conference held at the Imperial College of Science and Technology, London (4-7 July 1978) which highlighted the increasing impact of cryogenic technology. The second, the International Cryogenic Materials Conference held in Munich the following week, was primarily concerned with nonmetallic materials for use in support of this technology.

Over 250 conferees at the London meeting exchanged ideas and discussed future trends in cryogenic engineering. These ranged from sophisticated scientific experiments on spacecraft, included terrestrial applications such as power generation and transmission as well as food preservation, and extended to that fundamental ingredient of living—health.

In order to obtain the sensitivity required by complex data-gathering instrumentation planned for installation in future space vehicles, it is necessary to cool x-ray, infrared, or similar sensors to liquid helium temperatures. Presentations discussed the problems and current approaches involved in utilizing liquid helium in these and other applications. For example, the cryogenic system must be able to function in zero gravity and at the same time

withstand 20 G accelerations during launch. The system must have a high reliability (of upwards of three years), and must be able to operate unattended. As the liquid absorbs heat and boils into a gaseous phase some device such as a porous plug is needed to separate the gas from the liquid and to permit venting of the gas in such a manner that no torque is imparted to the vehicle. As if these were not serious enough problems, liquid helium at temperatures below 2.7 K undergoes transformation to a superfluid phase. In this phase the liquid has a very high thermal conductivity and exhibits a viscosity which is 10^6 times smaller than that of helium above the transition point. It then has the ability to form a thin film on the walls of a vessel and climb out of an open one. New cooling problems presented by this behavior require exploration including cooling ability as a function of film thickness as well as the superfluid's mechanical properties such as the rate of mechanical damping and surface tension.

The progress of superconducting technology as it struggles to break out of small-scale laboratory installations into larger commercial application was interesting. In this regard, at one point during a particularly informative discussion, the chairman solicited audience technological projections as to large-scale devices in their respective countries. In the UK a 100-MW ac superconducting generator is expected within about 10 years, Finland expects to have a superconducting motor in an icebreaker in this period, and similar projections were reported from the US, France, and the USSR. Several other countries reported ongoing paper studies, but clearly the trend although slow is toward large-scale superconducting machinery. In addition to motors and generators superconducting magnets are planned for large magnetohydrodynamic generators which are expected to convert 50% of coal energy into electricity (as opposed to only 35% from conventional plants). Fusion technology is also an application where superconducting magnets are expected to make an important contribution.

In order to realize fully the potential of this new technology, work is constantly underway to find wire that will carry higher currents in the lossless state. Conductors such as V_3Ga and Nb_3Sn can be made, but they have the drawback of mechanical brittleness. New techniques were described whereby the composite wire is wound in an unreacted state, when it is more flexible, and only after formation reacted to yield the brittle superconducting compound. By use of this technique, Nb_3Sn magnets have been prepared. The advantages are complete reaction and tight winding, the disadvantages a change in geometry and a deterioration of the insulation at the high-reaction temperatures required. V_3Ga with a reaction temperature 200°C lower than Nb_3Sn would be a very useful composite with superior characteristics in this application. In any event, the message coming through loud and clear is that NbTi will not be adequate for future large-scale devices. Instead, these will utilize conductors of materials such as Nb_3Sn and V_3Ga which have the capability of providing higher magnetic fields.

The development of superconducting power lines is continuing but at a reduced pace. Work on a flexible superconducting power line being built in the USSR was reported, but the general attitude seemed to be a watch and wait one with eyes turned toward the transmission line under construction at the Brookhaven National Laboratory. In this application as well as in other large-scale endeavors, the question of reliability was repeatedly raised.

Interesting applications of cryogenic liquids were reviewed. Liquid nitrogen is increasingly being used in food processing, both to fast-freeze food in factories and to keep the same food frozen while it is being transported to market. It can also be used to shrink fit parts and when applied to dies can increase extrusion rates. Medical uses of cryogenics were presented with vivid color transparencies dramatically pointing out the advantages of cryosurgery in certain cases. Essentially a probe is placed in contact with the tissue to be removed and then cooled to temperatures as low as liquid nitrogen. The time and temperature combination chosen depends upon the type and location of the tissue as well as the extent of the intended tissue destruction. The tissue frozen sloughs away within a day or so. While cryosurgery is bloodless and there is less trauma to the patient, the actual mechanism and details of what happens at

the interface between frozen and non-frozen tissue is not well understood, and work on this and related topics is progressing.

A look into the future of computer technology showed Josephson junction devices moving toward replacement of conventional silicon circuit elements. Compared to a two hundred thousand circuit machine using silicon dissipating 10 kW, a similar Josephson junction machine would only dissipate 3 W, although this would be into liquid helium. Because of the very low power consumption, computers could be made smaller and more compact, easing the problem of signal propagation delay from one part of the computer to another. The high speed of such a computer with clock frequencies of 100 MHz, low power dissipation and small size offer extremely attractive possibilities.

Turning to the Materials Conference at Munich, primary emphasis was on non-metallic composites. In general in this field in order to keep pace with the effort being expended to develop superconducting materials, a corresponding parallel effort should be underway for the development of insulators to be used at low temperatures since both thermal and electrical insulators are integral parts of cryogenic systems. But developmental work is slow probably because before a manufacturer will embark on such an effort, he wants to know what his potential market will be. On the other hand, the designers of cryogenic systems cannot predict the market because of many unanswered questions about low temperature properties of non-metallic composites. The Munich Conference was intended to ameliorate such problems by bringing together the interested parties and by providing accessible information in a Conference Proceedings.

The meeting covered two broad areas, the first, high polymers such as polyethylene and polycarbonates and the second, fiber composites such as carbon fibers in a carbon matrix. High polymers are under study, both to determine their properties at low temperatures and to discover techniques which will bring about certain structural changes and so modify and improve their properties at cryogenic temperatures. Some studies are examining the effect of cross linking the polymer chains, others concern the introduction of partial crystallization in the polymer system. Investigation of the mechanical properties of these polymers as a function of temperature has given clues to various motions of the molecular chain. As different modes such as twisting or reorientation are damped out by cooling, the material becomes more brittle. Cross linking and partial crystallization are the basis of attempts to relieve this brittleness, and to provide materials that are both more flexible and tougher at low temperatures.

In addition to work in progress on mechanical properties of non-metallic composites, the low temperature electrical properties are also under study, including ac losses that would be encountered using the different insulating materials in superconducting cables.

There is an increasing amount of effort on fiber composites with their great strength-to-weight ratio. However, problems arise with these materials at low temperatures. While material from two different manufacturers may have similar properties at room temperature, slightly different compositions or additives give different properties at low temperatures. Fortunately, however, the low temperature properties appear to be better than at first anticipated. In addition, there is a move toward categorizing and tabulating the low temperature properties of fiber composites which should help alleviate such problems.

The advantages of various types of thermal insulation for cryogenic use were also discussed, and polyurethane foam seemed to be widely used. Applications of polyurethane foam ranged from the insulation of large supertankers for transporting liquefied natural gas to future uses in liquid hydrogen powered aircraft where lightweight and good thermal insulating properties would be of great advantage. While lightweight foam is useful in certain applications, it is interesting to note by way of contrast that concrete structures have been used to store liquefied natural gas since 1962.

The presentations at the Cryogenic Engineering Conference were impressive and covered a wide range of topics. One was left with the feeling that both current and future problems in engineering application will be solved. The Materials Conference offered an opportunity to review the current directions of non-metallic composite work in support of

the cryogenic area and to see what progress is being made. Together the two Conferences promise well for the continued development of cryogenic technology. (Thomas L. Francavilla, Naval Research Laboratory, Washington, DC)

MATERIAL SCIENCES

MATERIALS PROBLEMS AT THE JOINT RESEARCH CENTRE

The Commission of the European Communities (more familiarly known under the general titles of EEC or the Common Market) sponsors a large amount of materials-related research in both the public and private sector, and most notably at two of the four components of the Joint Research Centre (JRC), located at Ispra in Italy, and Petten in the Netherlands. Those interested in information on the structure and mission of the JRC are referred to a recent *ESN* article by Rostron (*ESN* 32-2:44). In this article I will discuss some recent changes in the direction and intent of the materials programs, for there has been a fairly dramatic shift in research philosopy of the Commission, and in particular the purpose and goals of the Centre.

To illustrate this, I will first describe the research programs for the 4-year funding period 1973-76, and then contrast it with the latest 4-year program. For convenience of presentation I will consider the Petten and Ispra activities together, although the Ispra materials activity is about ten times as large (about 150 total personnel as compared to about 20). The two groups appear to work closely together, and the quality and direction of the efforts are similar, so this grouping is reasonable.

The program proposal accepted for the materials division in 1973 by the Council of Ministers of the Commission stressed problems in materials science of a long term nature intended to provide the general technical support for current and long-range development of advanced materials. The areas of research emphasized were the following: Radiation damage studies; surface reactions on advanced materials; mechanical properties of metals and composites; physical properties at high temperature; transport processes and structural behavior of metals and polymers; effect of structural changes and lattice imperfections on physical properties of material; and nuclear physics.

These programs were supported by a budget of about $14 million, of which almost 11.5% was for scientific equipment and instrumentation. Such a broad-based topic-oriented program provided great scope for the interest of individual investigators and a variety of fundamental studies were initiated. A good example is found in the subject of mechanical behavior. This produced, in part, studies of as-grown and artificial composites, and of high purity single crystals of vanadium before and after irradiation.

The composite program, supervised by Dr. G. Piatti, has been highly successful and has given appreciable visibility to the researchers at Ispra. Basic studies were carried out on oriented solidification of eutectics, particularly of those in which the fibers are intermetallics, to correlate solidification parameters such as thermal gradients, solidification rates, and impurities with the obtained morphology, diameter and length of fibers, interfiber distance, and the orientation relationship between fiber and matrix. These were followed by structure-property studies to determine optimum microstructures for specific applications both structural (e.g., mechanical resistance) and nonstructural, (e.g., magnetic and optical use). The specific systems studied ranged from the binary alloys $Al\text{-}Al_2Cu$, $Al\text{-}Al_4Ca$, $Al\text{-}Al_3Ni$, $Mg\text{-}Mg_2Ca$, $Ni\text{-}Ni_3Ta$ in which the structure is most often lamellar, to the more complex multi-component systems Ni-Ta-Cu and Ni-Ta-Cr-Mn. The microstructure of the last system is different from the others, consisting of either cells or dendrites, depending on the solidification conditions.

The systems based on Ni (or Co) have important uses as high-temperature structural materials for turbine blades, although much is yet to be learned on how best to insure long term stability of the microstructure under thermal and mechanical cycling. Another interesting potential application was for the system $Al\text{-}Al_4Ca$, which displays a

high degree of superplasticity and could thus be an important formability alloy. The properties of the solute calcium, i.e., abundance, lightness, and thermal insulation provide additional benefits.

At Petten, there was a long-term study, under the supervision of Dr. J. Bressers, on the purification and plastic properties of vanadium. Original interest in this material stemmed from possible applications as a high temperature alloy or as a containment material for fusion-reactor systems. Using high-purity single crystals produced by electron-beam zone refinement, he studied the effects of oxygen interstitials on the subsequent dynamical behavior of dislocations, as well as on slip plane and stress asymmetry during low-temperature deformation. A second study was the effect of oxygen and helium impurities on neutron irradiation-induced void nucleation in the temperature range $0.3T_m \lesssim T \lesssim 0.5T_m$, where T_m is the absolute melting temperature in degrees Kelvin.

Experimental results and modelistic calculations led to the conclusion that asymmetric flow stress behavior (i.e., the stress in one direction on a particular slip plane is not numerically equal to the stress applied in the opposite or anti-direction) is due to intrinsic lattice behavior, whereby the dislocation mobility is a function of the sign of the applied stress. The temperature dependence of the flow stress, on the other hand, is better explained by the presence of a dispersion of interstitial solutes and thus is due to extrinsic behavior.

These brief summaries do not do justice to the breadth of the program during the 1973-76 time period. The JRC scientists I spoke with were unanimous in their belief that they not only were performing important base line studies, but were also successfully addressing shorter term problems, as these arose.

It would appear, however, that this opinion was not totally shared by the several advisory committees who oversaw the technical progress of the programs and who reported directly to the Council of Ministers. With apparently little consultation with the research staffs, a decision was made that much of the effort was too unstructured and possibly too fundamental in its approach, and did not respond to the immediate technological needs of the European community, particularly in the area of power generation and transmission, which had become a major research and development goal of the Commission.

Responding to this change in policy, some program revision occurred in 1975-76, most notably the dropping of the one on vanadium at Petten. This was replaced with a new program devoted almost entirely to the evaluation and development of high-temperature materials. Some budget changes and "personnel integration" also occurred, with some reduction of the research staff largely by attrition.

The 1977-80 research program completed this shift in direction. No longer was materials research funded in its own right. Instead it was integrated into broad multi-disciplinary projects which encompass more specifically the total research effort of JRC, of which the materials program is only a small part; namely, 1) Reactor safety: Reliability and risk assessment; light-water reactor loss of coolant accident; liquid-metal fast-breeder development; fuel coolant interactions and core melt down; dynamic structure loading and response; structural failure prevention. 2) Plutonium fuels and actinides: Utilization of fuels; plutonium and actinide aspects of the safety of the nuclear fuel cycle; actinide research. 3) Nuclear materials and radioactive waste management: Long term hazards; chemical separation and transmutation of actinides; fuel materials management; decontamination studies. 4) Solar energy: Habitat and thermal conversion; solar irradiation; conversion processes. 5) Hydrogen: Thermomechanical processes for water decomposition; heat source coupling. 6) Conceptual studies of thermonuclear fusion reactors: Blanket nucleonics; heat transfer and energy conversion system; materials; stress analysis; safety and environmental impact; plant engineering; cost analysis and power requirements. 7) High-temperature materials: Effect of operational environments on mechanical properties; high-temperature failure modes; structure-property studies. 8) Environment and resources: Atmosphere; water; chemicals; agricultural resources. 9) Measurements, standards and references techniques: Measurement of nuclear data; nuclear reference materials and techniques; nonnuclear reference materials and techniques.

It is obvious from the titles that material studies will play a role of varying importance in these projects, for example it will dominate number (7), but will be of little importance in number (8). The major functional problem of how to integrate the materials groups into these larger efforts, many of which have been ongoing for several years under the dominant influence of physicists, is still ongoing. There is concern from those I spoke with, that their efforts will be relegated to a support status. Multi-disciplinary programs are so attractive in concept, but so hard to implement in practice. This does not mean they shouldn't be attempted, but it was suggested that the changes in program structuring could have been done more gradually and selectively, so as not to submerge the individual character of the materials program.

There also appears to be some confusion as to why, in their eyes, the materials effort has been relegated to a lesser role. One explanation, admittedly somewhat biased, is that members of the advisory committee, many of whom represent national laboratories or organizations who compete for EEC funds with JRC, hope to pick up some of the discarded programs for their own institutions. Whatever the reason, the EEC is moving towards the establishment of multi-disciplinary programs to attack technological problem areas. However desirable this may be, it should be balanced by a continued commitment to long term unstructured (not uncontrolled) fundamental research.
(I.M. Bernstein)

MATERIALS RESEARCH IN SPAIN

In pursuit of materials research in Europe one tends to place primary emphasis in Northern Europe. There is however a burgeoning if still modest activity in this field in the developing countries of South Europe. Spain is a good example of this with a growing commitment to both basic and applied research. In what follows our intent is to cover some representative ongoing research in Spain, and then to comment on the general environment for development of the research base there.

Materials research is centered in and around Madrid, with little evidence of any serious commitments towards developing similar programs in the regional universities. University City, in the center of that city, is the main focus with three separate institutions involved. These include two universities, the Universidad Complutense and the Universidad Polytècnica, and a government-supported research laboratory, the Centro Nacional de Investigaciones Metalúrgicas (CENIM). Also in Madrid is the nuclear physics establishment, the Junta de Energia Nuclear, while on the outskirts of the city, there is the relatively new Universidad Autonoma, founded about 10 years ago. We will not discuss the reasons for having so many apparently parallel institutions in competition for support and high quality students, for this is a subject probably best left to the historical observer specializing in the analysis of the pulls-and-tugs of institutional bureaucracy. We content ourselves with the science, first considering materials science, normally found within physics departments and then with metallurgical studies at the universities and CENIM.

Solid State Physics. A major physics division is at the Universidad Autonoma under the chairmanship of Professor N. Cabrera, who recently returned to Spain after many years in England and the US, and who also holds the position of Dean of the Faculty of Sciences. Within the division there are six departments several of which are connected with solid state physics. The heads of these departments tend to be relatively young scientists who have spent several years abroad—usually in the US.

Professor J. Rojo directs a group of about 10 people working on surface physics. An initial government grant allowed them to purchase and make operational 3 high vacuum systems. Their interests are in the properties of metals and alloys that affect catalysis and corrosion. In particular, they have been producing radiation damage by bombarding simple metals and alloys with 1-keV ions. This leads to clusters of lattice defects that can then collapse to form dislocation loops within 40 to 50 Å of the surface. By annealing and measuring the variation in the sticking coefficient of gases, such as H_2 or

ethylene, as the defects anneal out, information can be obtained on the role of specific defects in surface reactions. They are also studying the segregation of impurities on metals using Pt laid down on a Cu surface. Another system of interest is MgO in which a deficiency of Mg^{2+} has been induced on the surface. The surface reactions of the excess O^{2-} produced are then monitored.

The Applied Physics Department, directed by Professor F. Rueda, concentrates in areas of government interest or in which there are opportunities for cooperation with Spanish industries. Principally their efforts are concentrated on solar cells, Schottky diodes, and tantalum oxide capacitors. They claim to have made polycrystalline silicon solar cells with 7% efficiency, using solar grade silicon and without an antireflection coating on the cell.

In the silicon Schottky diode work a high vacuum operation is necessary and the silicon is cleaned with argon-ion bombardment before depositing various metals. For high peak current diodes (50 A in a 3-mm-diam. diode) they use Cr; Mo is used for medium power (1-10 A), and Pt-Si is used for low powers for which fast response is often essential. The laboratory has simple but effective auxiliary processing and measuring equipment such as cryostats, Hall effect and conductivity apparatus, and optical apparatus for spectral response.

Of special interest to the Department are the deep trap levels in the silicon solar-cell work. In polycrystalline materials they find traps caused by grain boundaries, at 0.25, 0.52, and 1.24 eV. They are studying a new method for obtaining these level positions. This involves measuring the second derivative of the current with respect to the applied voltage as the voltage is varied across a 10-20-μm thick sample at 77 K. It is almost a tunnelling measurement that picks out the traps. The advantage of this technique as compared with the more common transient capacitance measurement, is that trapping levels close to the interface between silicon and an electrode can easily be seen. At present they are attempting to put this technique on a solid footing by comparing it with the transient capacitance method on well-characterized materials.

The studies of tantalum oxide capacitors use electron microscopy and surface physics techniques to probe the processes that commercial producers have developed empirically. A practical problem is to determine whether the electrical breakdown that now limits these devices is due to the incorporation of TaC or other impurities.

The Optics and Structure of Matter Department is directed by Professor F. Agulló-Lopez. This group studies the nature of divalent impurities and their role in the optical, thermal, mechanical, radiation damage, and electrical processes of alkali halides. This is a formidable problem that one would not expect to yield its secrets as a result of a few brilliant and incisive experiments. As a new venture, the group is beginning to turn its attention to the study of similar phenomena in ferroelectrics.

Another research group doing work in materials science is found in the Physics Division of the Junta de Energia Nuclear in Madrid under the direction of Dr. J.L. Alvarez. Some years ago Alvarez and his associates proposed that thermoluminescence in radiation-damaged alkali halides occurred when an interstitial halogen atom diffused to a halogen vacancy containing an electron (the F-center) and recombined with it to reform a normal portion of the lattice. This suggestion has proved to be a very fertile one and has helped to tie together two usually distinct sets of phenomena. Color centers in alkali halides are predominantly the various combinations of F-centers that are seen optically and in spin resonance. The complement to these F-centers would be interstitial halogen atoms. They are difficult to see optically and at room temperatures they probably diffuse together to form clusters. These optically elusive interstitial centers are, however, dominant in pinning dislocations and determining the mechanical properties of the alkali halides. Since the Alvarez explanation of thermoluminescence invokes the destruction of both a color center and an interstitial, it joins the optical and mechanical properties of the crystals in a measurable way.

Alvarez and his associates have been exploring the implications of this model. Their most recent efforts have shown that the luminescence spectrum

seen in thermoluminescence, when the interstitial moves to the F-center, can also be produced by shining light into the F-absorption band. In this case the excited F-center is able to diffuse to the interstitial and the usual recombination luminescence occurs. They have also studied thermoluminescence in KCl:Ca and KCl:Sr. Each of these materials shows a different thermoluminescence pattern and they both differ from pure KCl. The proposed explanation is that the interstitials are bound to the Ca and Sr impurities with varying binding energies that can be deduced from the thermoluminescence glow peaks. Alvarez and his group intend to measure the mechanical properties of their crystals to look for correlations between optical and mechanical properties. Based on their model, most of the varied optical and mechanical phenomena in alkali halides can be described as a function of temperature and irradiation dose by simple rate equations. It is planned that this kind of work will be extended to MgO.

Metallurgy. In the somewhat more prosaic world of the structural integrity of metals and alloys, much more attention is being focused on problems directly related to industrial processes or to applications using Spain's natural resources, of which unfortunately there are not a great many. These latter efforts are concentrated at CENIM, and center around investigations on the mechanical properties of non-ferrous metals such as lead and antimony, and on means of extracting and refining them (as well as Ca and Mg) from low-grade ores, as well as the refining of mercury.

The structure-property studies are quite straightforward and include recrystallization kinetics and mechanistic studies of copper and how these are affected by trace impurities and cold work, the development of Pb-Sb, Pb-Ca-Sn, and Zn-Cu-Ti alloys for low melting casting alloys and solders, and the effect of Cu and Cr additions on the strength, toughness, and stress corrosion susceptibility of Al-Zn-Mg alloys.

The extractive processing of low-grade ores involves the use of complex salts to improve both the kinetics and the yield. While the work has only recently begun, it appears promising.

At the Metallurgy Department of the Universidad Complutense, most of the effort is directed toward an understanding of the metallurgy of welded joints. This research is supervised by Prof. F.A. Calvo and has been ongoing for a number of years, supported for a time by the US Army Research Office. Although he is now deeply involved in administrative matters, particularly the formation of yet another university in Madrid, some research in the area continues. The major interest has been the development of an experimental technique allowing them to relate the original microstructure at a specific location of the specimen to the microstructure in that area after a given number of thermal cycles. This should mirror the effects found after multipass fusion welding, particularly in the nonmolten heat affected zone (HAZ). Called the "Polished Surface Technique," it entails the use of programmed thermal cycles on a part of a polished metal specimen surface. The thermal cycles are produced by discharging an electric arc between a tungsten electrode and the specimen, under an inert atmosphere. Water cooling the disc-shaped specimen allows both the heating and cooling rates to be controlled. Further, by discharging the arc on the opposite surface to that polished, any microstructural changes can be continually monitored as a function of the severity and number of thermal cycles.

In their studies on low-carbon steels, they observed the formation of a nonequilbrium morphology of pearlite and martensite that allowed them to identify regions that had been subjected to dramatically different cooling rates. This in turn was related to local plasticity in the retained austenite prior to the formation of martensite, and to the formation of high-temperature grain boundary cracks promoted by local transformation stresses.

In copper, the brittleness of grain boundaries in the HAZ has been related to the formation of a low melting Cu-Cu_2O eutectic which can penetrate grain boundaries as a result of capillary action. Hydrogen was also shown to be dissolved in the prematurely molten eutectic, and it could later combine to form gas bubbles and thus porosity in the fusion zone and HAZ. Similar eutectic formation was observed in commercial purity aluminum and was also sug-

gested as the reason for observed grain boundary brittleness in these alloys. Future studies are planned with increased emphasis on phenomena in the fusion zone and on the effect of different welding gas atomspheres on subsequent microstructural effects. The Department's efforts are modest but interesting.

At the Universidad Politécnica a new development is a shift in direction in the Department of Applied Physics of the School of Road Engineering. The group under the direction of Prof. M. Elices was until recently a traditional Civil Engineering Department concerned with such topics as stress analysis and instabilities of large structures such as bridges. Reflecting the lack of job opportunities in this area as bridge building commitments decreased, the group has slowly evolved into one concerned with material properties and reliability. It is likely that another reason for this shift is the filling of a recognized need for more materials education and research.

Their efforts have centered around the behavior of reinforcing steel bars in both prestressed and unprestressed concrete. Concrete is a very common building material in Spain, and this area is one that allows them, of course, to make full use of their civil engineering backgrounds. Elices and V. Sanchez-Galvez have developed a model to describe the stress-relaxation of steel, particularly how it is affected by initial stress level and temperature. Such a process has important design implications for prestressed concrete. Their model is a fairly straightforward application of dislocation rate theory in which the relaxation processes are related to the thermally activated motion of dislocation through its rate parameters, the activation energy for motion, temperature strain, strain rate (dislocation velocity), and the stress dependence of the velocity. Their final formulae describe the stress dependence at constant stress of the plastic strain, which is a direct measure of stress relaxation. They have obtained good agreement between theory and experiment on eutectoid (0.8%C) steel, the commonly used alloy for reinforcing bars.

Another problem encountered in composite steel-concrete material is moisture-induced corrosion at the interface between the steel and the concrete. They have established an extensive test program to evaluate corrosion and stress corrosion cracking in eutectoid steels in both moisture-saturated air and a variety of acidic solutions that can accelerate both processes. Such variables as the surface finish of the bar, its residual and applied stress level (both static and cyclic), and temperature are being systematically evaluated.

A new area in the group's expanding activities is the study of the tolerance of gas pipe-line steels to hydrogen. Spain is almost totally dependent on natural gas from Algeria and is aware that the vicissitudes of the geopolitical scene could in the future jeopardize supply. They, as well as a number of other European countries, are evaluating the possibility of admixing hydrogen with the natural gas, with the long-term goal of moving towards a hydrogen-based energy system in which the hydrogen is produced, say, by electrolysis of water using off-peak energy from nuclear or hydroelectric sources. However, a gas is not a gas is not a gas, and much remains to be learned about whether existing or projected pipeline systems are or will be susceptible to hydrogen embrittlement. This effort is a joint project with Elice's group, Butano S.A. a major Spanish natural gas supplier, and a group at Carnegie-Mellon Univ. Pittsburgh PA. There is little doubt that the efforts at the Politécnica are the most vigorous and interesting of the metallurgy programs that were visited in Spain.

The Future. What of Spain's future in materials research, and indeed in research in general? Any answer to this must come as much from the traditions of the past as from plans for the future. It is our opinion that they face many difficulties as they attempt to become a technologically developed nation.

A major problem is that Spanish culture is traditionally not centered on science but on the humanities. Spanish heroes tend to be artists, writers, or musicians. As pointed out in an *ESN* article two years ago (*ESN* 30-3:98) it is only recently that universities here enlarged their traditional faculties of medicine, law, theology, and philosophy to include science. To these problems one must add the disruption of the Civil War that ended in 1939 leaving the University system in chaos.

Physical plants were destroyed, the faculties were dispersed, and respect for the institutions was at a low ebb. As a result one sees only recently the fruits of the rebuilding program that has been ongoing for many years.

The net result of all this for science in Spain, is that there is no grand tradition to look back on. There is no continuity of teachers and students forming a pyramid in time. Indeed, there is a dearth of experienced scientific leaders in the age group of about 50 to 65 who should be helping to establish academic policy in the government, chairing planning committees, and helping to create standards of excellence for young people, thereby giving science stature in the culture.

There are other implications of the somewhat second class stature of science in Spain. One is that, in general, research is not well supported. The fraction of Spain's gross national product given to research is said to be well below the European average. Also the connections between industry and research scientists are tenuous at best. This is partly because most Spanish industry is not involved in high technology products or markets, but rather imports those needed.

Finally, the university system itself can discourage research. In a typical university research group about half of the people occupy tenured positions; the remainder are primarily young graduates on yearly contracts who are looking for tenure. As pointed out in an earlier note by one of us (*ESN* 32-3:97), there is protracted public set of examinations that are given for each new appointment to these positions. As presently constituted the examination emphasizes strongly an encyclopedic knowledge of a discipline and an ability to prepare lectures quickly and deliver them forcefully; the candidate's research record is of secondary importance. As a result, the ambitious young scientist is apt to be preparing constantly for these examinations rather than pushing hard on research. When he does succeed in winning an appointment, it is apt to be in a small isolated school with little equipment or funding to initiate or continue a research program. It is possible that the form of the examination may alter to include a more balanced emphasis on research accomplishments as a result of new laws to cover universities that are expected soon. However, the necessity for a public examination of some kind for permanent positions in all government institutions (including universities) is said to be essential and not likely to change since it appears to be a response to a cultural tendency to favor friends and family.

Surrounding all of science in Spain is the acute awareness that much is changing. For some the changes are too fast; for others too slow; for everyone the future is uncertain. Will there be a thriving scientific research community in Spain in five years? What form will it take? Those questions bedevil a great many bright young men and a surprisingly large number of bright young women in Spain whose careers in science—if any—seem to them to be hanging in the balance. (Clifford C. Klick and I.M. Bernstein)

MATERIALS RESEARCH AT ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

A visit to RAE Farnborough, located 35 miles southwest of central London, gave this veteran of the California freeway system the chance to venture forth on the "motorway" for the first time in my newly-acquired 10-year-old Riley 1300. At the end of the ordeal I was welcomed by my host for the day, Dr. R.J.E. Glenny, Head of the Materials Department at RAE, and my mind soon turned from thoughts of lorries and roundabouts to composite materials and such.

In recent years, the strongest area of materials research at Farnborough has been carbon fiber reinforced plastic (CFRP) composite materials, as reported here several years ago by I. Wolock (*ESN* 28-5:161), and this continues to be the single most-emphasized topic, with the effort amounting to about 15% of the 80 professionals and 60 support staff in the Materials Department. The Department is divided into four operating divisions: Metals, Physics, Non-Metallic Materials, and General Chemistry. There is also, since earlier this year, a new administrative division for extramural research and all four operating divisions have extramural projects.

Contributions to the composites effort come from all four divisions, although most of the work is still in

Non-Metallic Materials and Physics where the work originated about 15 years ago, with the pioneering effort on carbon fiber production by William Watt and Leslie H. Phillips, both of whom subsequently received the Order of the British Empire (OBE). Watt has now moved on to the University of Surrey, where he is still involved in some extramural work with RAE. (See *ESN* 28-5:161 for further description of RAE's earlier work on fiber technology).

A dominant theme in materials research at RAE is the development of basic new techniques for characterizing materials of all kinds, be they metals, polymers, fuels, textiles, etc. For example, the Carbon Fibres section in the Physics Division is attempting to develop methods that give detailed characterization of the surface of carbon fibers used in CFRP. Dr. John Harvey explained that it has been found that CFRP properties are quite sensitive to the surface pretreatment given to the fibers. The problem is perceived to be that if the surface treatment is "too good", the fiber-plastic interfaces in the composite become too well-bonded, so that cracks propagating in the matrix are not stopped when they encounter fibers. Various techniques are being used to determine the key elements in the nature of the fiber surface, including surface area measurements, dye absorption, water absorption, ESCA, etc, with extramural support at the Universities of Surrey, Oxford, and Newcastle upon Tyne.

Another Physics Division section, Strength and Fracture of Metals, headed by Dr. John Easterbrook, carries out both theoretical and experimental work in fracture mechanics, with an emphasis on the analytical calculation of stress intensity factors for complex situations, and is exemplified by the work of D.P. Rook, C. Wheeler, and others. The main emphasis of the experimental work here is to establish valid testing methods for the cracking behavior of materials, with the key tool being "R-curve" plots. Collaborative work in this area is underway with several other groups in Europe, notably at NLR (National Luchten Ruimtevaartlaboratorium) in the Netherlands. There is great interest in developing standards for aircraft materials evaluation, and RAE is working through European organizations such as AECMA (European Association for Aerospace Construction Materials) to try to establish uniform and valid test procedures. Easterbrook indicated that in the future variable amplitude high-cycle fatigue studies will probably be emphasized, in which crack growth rates may be as low as 0.1 nm per cycle. He suggested that the variable amplitude case tends to make the concept of a threshold stress meaningless.

Several other interesting pieces of work relevant to composites are taking place in the Physics Division. For example, G. Dorey of the Carbon Fibres section is attempting to evaluate the notch sensitivity of CFRP; an interesting twist to this work is the employment of an effective "plastic zone" correction to account for damage around the crack tip in a composite. This project seems to embody both the composites-structure and general fracture mechanics capabilities of the Division. Also, Sarah M. Bishop, in the Fracture group, is using photoelastic Moiré techniques to follow the development of strain around crack tips in CFRP.

Composites-relevant research is even more extensive in the Non-Metallic Materials Division, where the interest is primarily in polymer resins. As with many of the materials research projects at RAE the work in this Division takes a rather fundamental approach but is typically aimed at a practical problem. For example, there is great concern about quality control for epoxy resins used in CFRP, since variability in resin properties can significantly affect composite properties. In this respect Dr. Dave Thomas, the Division Head of Non-Metallic Materials, indicated that a wide range of quality control tests are being evaluated, for while features such as viscosity, color, molecular weight distribution, impurity level, etc., vary widely in as-supplied resins it is not clear just which properties should be monitored for quality control.

The Non-Metallic Materials Division is also concerned with environmental interactions, such as outdoor weathering of CFRP, rain erosion, and (dry) wear of materials of all kinds. This work reflects another common theme in RAE materials work, namely the extension of service life. In several cases, this is approached by attempts to develop meaningful accelerated tests. As is typical at RAE, this tends to lead to more fundamental studies than would be expected on the basis of the real-world problem.

There also is a large activity in polymeric adhesives in the Non-Metallic Materials Division, covering the bonding of light metal alloys and CFRP, to themselves and to each other. Part of this work is being done in conjunction with the Army Materials and Mechanics Research Center (AMMRC). Another section is devoted to the study of elastomeric polymers, mostly for use as sealants in aircraft fuel and hydraulic systems; here a major concern is polymer stability in the particular service environment. There are also investigations of higher temperature polymers, such as polymides, for possible future replacement of epoxies in CFRP, and of the mechanisms of their degradation at high temperatures.

In toto, the Non-Metallic Materials and General Chemistry Divisions cover a wide range of physical, inorganic, and organic chemistry problems relating to the need for new or improved non-metallic materials. The materials of interest are very diverse, including structural adhesives, elastomers, fiber reinforced plastics, thermoplastics, high-temperature resins, and (in the General Chemistry Division) fuels and textiles. Two of the areas being served by work in the General Chemistry Division are the weathering and tearing properties of textiles (such as for application in parachutes) and the anti-misting effect of polymeric fuel additives (relative to prevention of fires after aircraft crashes). This Division is also active in the synthesis of polymeric materials for application as structural adhesives, elastomeric seals, and laminating resins. Allied research concerns the relationship between molecular structure, transition, temperature, and bulk properties of polymers.

The Materials Department is also very active in the battery field. Although most batteries are at least partially metallic in nature, this section, headed by Mr. E.J. Doran, is in the Non-Metallic Materials Division. The section has a large extramural program concerned with the usual range of contemporary aircraft and guided weapons applications.

The Metals Division, headed by Mr. C.A. Stubbington, has as one of its responsibilities the investigation of materials aspects of aircraft accidents. Dr. Peter Forsyth, who is well known in this field, is developing advanced quantitative fractographic methods for the investigation of fatigue failures. Striation-counting techniques are used to develop crack growth rate curves and the fractographic observations are compared with the actual spectrum loading history. In this work, the earlier stages of fatigue are of great interest. Special attention is being given to crack propagation in the vicinity of stress raisers. Ultimately, RAE workers would like to be able to connect the results of physical fractographic examination to a theoretical model for life behavior. There is some cooperation in this regard with the fracture mechanics group in the Physics Division. Other work in the Metals Division is involved with microstructure-mechanical properties relationships in steels and titanium alloys, with fabrication, and with corrosion prevention.

In addition to the work in the Materials Department that has been described here, a significant effort in nondestructive evaluation (NDE) is underway in the Structures Department in a group headed by Dr. David Stone. This includes some interesting work on NDE of CFRP, for example.

The full range of activities at RAE includes materials problems related to both civilian and military interests and in some cases both are served by the same work, one factor influencing this integration being the nationalization of the British aircraft construction industry as embodied by the British Aerospace. Thus, while civilian and military work are under the separate auspices of the Ministries of Industry and Defence, respectively, the results are often mutually applicable, for example that in aircraft skin materials, failure investigations, aircraft fuel flammability studies, and batteries. Interestingly, while much of the military-applicable materials work is unclassified, some commercial work is confidential for proprietary reasons.

As mentioned earlier, many of the materials programs at RAE are related to establishing means of quality control in order to reduce variability in materials behavior. Another common theme is an interest in extension of the service life of materials of all kinds, be they textiles, epoxy resins, or structural metals, and the common approach is to develop basic material testing procedures that allow life prediction. Thus fatigue life models are formulated for metals, quality control techniques for polymer resins, and tear tests for textiles. Indeed, the RAE materials effort is literally one of quality. (Jeff Perkins)

CORROSION RESEARCH IS IN HOT WATER AT THE NATIONAL PHYSICAL LABORATORY

No, the Department of Industry hasn't cut off funds. In fact the "hot water" situation at NPL has existed for more than thirty years, as I found out during a recent visit to the site in Teddington (about 15 miles west of Central London). The visit gave me a chance to review one of the longest-running and most extensive research activities on corrosion in high-temperature waters.

Historically, interest at NPL in the aqueous corrosion of metals at elevated temperatures derives from two early pieces of applied research on boiler corrosion: 1) a study of the corrosion of locomotive boilers carried out before WWI on behalf of the London, Midland, and Scottish Railway, and 2) an investigation of the corrosion of mild steel tubes in Scotch Marine Boilers carried out shortly after that war for the British Shipbuilding Research Association. These studies exposed the dearth of information on material behavior under boiler conditions, and also the dangers of trying to extrapolate corrosion behavior from lower temperatures. For example, from their behavior at ordinary temperatures, we would not expect copper or graphite to be compatible with iron, but copper endplates are satisfactorily used with steel tubes in locomotive boilers, and graphite paints have been used on steel boiler shells. Also, increases in temperature can lead to potential reversals, such as between iron and zinc, in which case galvanizing loses its protective effect. Over the years, continuing NPL work in the area of high-temperature aqueous corrosion has resulted in considerable expertise in this area.

At the present time, hot-water corrosion work at NPL is centered in a Corrosion Prevention section of the Division of Materials Applications. The Division Superintendent, Mr. B.E. Hopkins, noted that as a whole, the corrosion laboratories at Teddington represent one of the oldest continuing corrosion research activities in the UK and probably in the world. The activity can be traced to 1924 when the Department of Scientific and Industrial Research formed a Corrosion of Metals Group to increase understanding of corrosion and thereby form a basis for developing methods of prevention. This work was initially based in the Metallurgy Department of the Royal School of Mines of the University of London, but was moved in 1928 to the new Chemical Research Laboratory (CRL) at Teddington, which shared a site with the National Physical Laboratory (NPL). CRL was subsequently renamed the National Chemical Laboratory (NCL) in 1957, and in 1965 NPL and NCL were amalgamated as NPL and the work on corrosion and oxidation was continued in the Metallurgy Division. There are now both Corrosion Prevention and Oxidation Prevention sections in Hopkins' Division. These and a section on High-Temperature Materials (referring to superalloys and such) are jointly headed by Dr. T.B. Gibbons.

In recent years the work of the Corrosion Prevention section has extended studies in aqueous solutions to temperatures as high as 350°C. There are many special aspects to this work, including *in situ* electrochemical measurements and visual observations, and the evaluation of flow effects, heat transfer effects, and inhibitors. In these efforts, the philosophy is to maintain a balance between studies of mechanisms controlling corrosion and oxidation processes and methods of preventing them. Also, use of the research personnel and facilities to meet industrial needs has always been a feature of the NPL's activities. The main thrust is to develop reliable equipment and data for industrial applications in important technological areas. The problems of high-temperature corrosion in natural waters are relevant at the higher temperatures (up to 400°C) to the operation of boilers and heat exchangers and at more modest temperatures (up to 100°C) to the satisfactory running of domestic central heating systems and engine cooling systems.

The work does not always pursue basic corrosion mechanisms, but it is clear that over the years NPL researchers have become experts in methods of testing in hot waters. In such tests, special considerations must be given to containers, electrolyte stability, reference electrodes, heat transfer, etc. The experimental apparatus developed by NPL workers are strikingly clever. There are a number of unique experimental designs being used, and it is obvious that considerable thought and skill has been applied to make the facilities as dependable and versatile as possible.

There are special apparatus to study heat transfer effects, a pressurized-flow loop with segmented test section for studies of inhibitors at up to 120°C, a high-temperature flow loop for temperature up to 350°C, and a number of other special autoclaves and pressurized vessels.

Mr. A.S. McKie escorted me on a tour of the high-temperature (up to 350°C), high-pressure (up to 1000 psi), flowing (up to 3 m/sec) water loop. This, along with several other autoclave-type apparatus and associated electrochemical monitoring equipment, has been developed largely by McKie and Dr. P.E. Francis. The need for this high-temperature loop stems from the importance of fluid flow in many high-temperature plants. The facility is outfitted for television and ciné viewing of the specimen surface through a sapphire window. Video tapes have been made of the nucleation and growth of corrosion products on pre-polished and etched mild steel in aerated distilled water. Such films provide insight about flow and temperature effects, and allow base metal microstructural correlations for the origin of film formation. In order to minimize contamination of the solution by dissolution of the loop material, the principal components are fabricated in Nimonic alloys, which are quite resistant in neutral and alkaline solutions of low and high chloride concentration. The facility is an extremely well-built and instrumented permanent-type facility that already has served for several years, and will continue to be of value in the future.

As one would expect, considerable expertise has evolved at NPL on the subject of reference electrodes for electrochemical studies in high-temperature systems. Both internal (reference electrode under the same conditions as the working electrode) and external reference electrodes have been studied. The case of internal electrodes has been studied in detail by NPL workers, notably Francis. One of the problems with conventional reference electrodes is that the chemical constituents can introduce ions that are extraneous to the process being studied, and because solubilities and diffusion rates increase greatly with temperature, contamination of the test solution can easily occur. Suitable barriers to prevent ionic diffusion are difficult to construct. Other workers have overcome these problems by using Pt as the reference electrode, which readily becomes a H_2 electrode at high temperature. Francis has recently been studying the electrochemical behavior of Pt reference electrodes in oxygenated solutions of (0.1 M) sodium hydrogen carbonate ($NaHCO_3$) at temperatures in the range 150-250°C. The electrode is not thermodynamically reversible but can provide a useful reference potential for electrochemical studies.

The use of a reference electrode at the temperature of the working electrode has the advantage of avoiding unknown thermogalvanic potentials. However, there are few electrodes available for high-temperature use, particularly in oxygenated solutions. NPL workers have developed the Ag/AgCl system for use up to about 250°C. This electrode is relatively non-susceptible to hydrolysis in the mildly alkaline solutions of interest, and there is low solubility of silver chloride in water up to about 250°C. The Ag/AgCl electrode has been used at NPL to develop galvanic series for metals at 150°C and 250°C. The results have indicated that bimetallic corrosion may be less troublesome at these temperatures than at ordinary temperatures. At sufficiently high oxygen pressures the pressure dependence of electrode potential suggests that many metals act merely as oxygen electrodes, that is, their potentials are in the passive region, and this situation is obtained more readily as temperature increases. Above 250°C, the increase in solubility of silver chloride renders the Ag/AgCl electrode ineffective. Therefore, it has also been developed for external use in several configurations and has been used to monitor systems operating at temperatures up to 400°C and pressures up to 23 MPa.

Another problem inherent in high-temperature, high-pressure corrosion research is that the electrolyte in the sealed vessel may become ionically contaminated and/or depleted because of the reactions. This is a particular problem when it is of interest to work with low controlled concentrations of oxygen. Losses of oxygen or water vapor, or of carbon dioxide in the case of sodium bicarbonate solution, can have significant effects, even in a perfectly sealed autoclave, because of expansion of liquid and evaporation into the space above the liquid. This

problem is overcome at NPL by using a filled pressure vessel operated at a pressure above the saturated vapor pressure of the solution to avoid formation of a steam phase. Also, it is possible to refresh the solution during the experiment.

The effect of heat transfer at the metal-solution interface has been studied at somewhat lower temperatures by A.D. Mercer. Effects on corrosion have been studied using (a) corrosion samples in a uniformly-heated bath, as compared to (b) heated corrosion samples in a cooler bath. These experiments have both practical and theoretical value. Both heat transfer cases (with and without a sample-electrolyte, ΔT) have relevance to applications. The effects of heat transfer for the finite ΔT case are of particular interest with respect to attendant mixing and mass flux considerations; an example is the case of inhibited systems, such as with coolants. Generally, metals corrode substantially more rapidly in the heat transfer case as compared to the no-heat transfer, but NPL work has not pursued the basic mechanisms of this effect.

Mercer also outlined the NPL program on inhibitor evaluation, which has four stages of increasing sophistication. First, inhibitors are screened for their effect on the corrosion rates of metal coupons under non-heat-transfer conditions. Then, inhibitor formulations that show promise are examined under conditions of metal-to-coolant heat transfer, by the use of cartridge heaters within cylindrical samples. In the third stage, the surface temperature of heated samples is measured (by extrapolation from measurements by internal thermocouples) in static conditions. And finally, heat flux and surface temperature effects are evaluated under forced convection conditions in a pressurized PTFE loop at solution temperatures up to 120°C and flow rates up to 2 m/sec. In this loop, as in the high-temperature (350°C) one described earlier, the samples are flush with the walls of the test section so that there is no hydrodynamic disturbance, and the specimens are observable during test. Thus, in the ultimate experiment it is possible to approximate the service behavior effectively under very controlled conditions of coolant composition, temperature and pressure, metal surface condition, heat flux, fluid flow, and surface temperature.

All the NPL high-temperature work shows considerable attention to scrupulously experimental details. For example, regarding the fundamental role of temperature and its effect on corrosion rates, the general behavior is for corrosion rate of many metals to increase with temperature. However, the archival corrosion data for mild steel in pure water show corrosion rate increasing with temperature to a peak near 80°C then falling off again as temperature increases. This has been interpreted as due to decreased solubility of oxygen with increasing temperature, which offsets the increase in oxygen diffusivity. NPL work, however, has shown that whereas this maximum occurs if the testing is done in the historically-used silica glass tubes, it does not occur if testing is done in pure quartz tubes. Thus the decrease in corrosion rate in glass tubes above 80°C is attributed to dissolution of silica from the glass at high temperatures and inhibition of the corrosion process by film formation on the metal samples. Thus it is important to use vessels of quartz or another inert material to avoid such complications. NPL work has been consistently careful about such details.

Another NPL researcher in hot water is Dr. J.G.N. Thomas who is carrying out electrochemical studies in natural waters up to 90°C. This work is primarily concerned with the stability of protective surface films. Copper (pipes) and iron base (radiator) materials are emphasized, and special care is taken to maintain solution chemistry during potentiodynamic experiments. Thomas has been investigating the pitting propensity of copper, aluminum, and mild steel in waters containing bicarbonate and chloride ions, the predominating ions in natural waters. He pointed out that the corrosion of metals in natural waters depends to a large extent on the way the metal air-formed oxide behaves on immersion, and on the properties of films formed subsequently. Thus, breakdown and Flade potentials have been measured under a variety of conditions. Recently, Thomas has been looking at the effect of O_2 concentration, which is relevant to closed water systems in which O_2 tends to be completely used.

In closing, it should be noted that in line with the role of NPL as the UK standards laboratory, the responsibility

of the Corrosion Prevention section is to develop standard test procedures and data. In addition to this type of work, which is supported by the Engineering Materials Requirements Board of the Department of Industry, a significant portion of the effort is devoted to the study of problems presented to the Laboratory by outside customers. In both cases, the UK position is that a significant national economic advantage can be gained through a concerted battle against industrial corrosion and that there is a great need for basic data for use in plant and equipment design and operation, i.e., for sound advice in materials selection and operating conditions. In the case of the high-temperature aqueous operating environment, there are numerous important areas that are of continuing interest, such as central heating systems, engine coolants, boilers, and steam-raising plants. These problem areas, together with the past research successes and the wide variety of specialized research equipment at NPL, assure that corrosion research at NPL will comfortably continue in hot water for years to come. (Jeff Perkins)

MODELING AND PREDICTION OF FRACTURE TOUGHNESS

The material property that characterizes the resistance of a material to fast fracture is its work of fracture, G_{IC}, or equivalently its fracture toughness, K_{IC}. G_{IC} varies in magnitude from about 2 J/m^2—little more than the surface energy of the solid—for ceramics like ice, to over 10^6 J/m^2 for the toughest steels. The development of ceramics for load-bearing structures, the wider use of polymers and composites, and the development of very high-strength metallic materials all depend on an understanding of the physical basis of the work of fracture, and of how it can be manipulated. Thus the EUROMECH 108 Colloquium on "Modeling and Prediction of Fracture Toughness" was primarily concerned with toughening mechanisms in high-strength materials. The Conference brought together fracture researchers from four areas: metals, ceramics, polymers, and composites. One of the main aims of the organizer, Prof. M.F. Ashby (Cambridge Univ. UK), was to encourage an exchange of ideas and to bring out common ground shared by them. While the various areas are clearly bound together by the Griffith approach at the macroscopic level, at the microscopic level issues differ greatly. The stated goals of the Colloquium, to pool accumulated experience and evaluate progress in understanding toughness, were accomplished in a limited-attendance, Gordon Conference-style conclave at Cambridge University 4-6 September 1978. There were no written papers and proceedings will not be published. Approximately 40 attendees were quartered in Corpus Christi College, founded in 1352, where the monk-like living style served to inspire maximum attention to scholarly matters.

The theme of the Colloquium was to review and compare physical models relating the work on fracture to microstructure, which have been independently developed and tested by metallurgists, ceramists, and polymer and composite scientists. The meeting was organized so that approximately equal time was devoted to each class of materials. Ashby introduced the Conference by pointing out that ideas differ for the various classes of materials regarding ways to toughen them. With metals the basic idea has been to increase resistance to cracking by enhancement of crack tip plasticity. For polymers, however, the reverse is true, and for this class the aim is to inhibit the inherently high plasticity of many pure polymeric materials by filling with some sort of dispersed particulate. Yet another approach is taken with ceramics, whose inherent brittleness is handled essentially by evolving design criteria that allows one to live with this type of behavior. These various approaches constitute a wide divergence of ideas, and Ashby suggested that it might be very productive to begin to sort out a unifying basis for toughening of materials in general.

Much of the concern of those discussing metal fracture dealt with nonlinear fracture mechanics, i.e., the extension of linear elastic fracture mechanics (LEFM) to situations involving large-scale plasticity to cope with intermediate-strength structural metals. The lead paper of the Conference was presented by Prof. John W. Hutchinson (Harvard University, currently on sab-

batical leave at the Technical Univ. of Denmark) who reviewed some aspects of nonlinear fracture mechanics, particularly the applicability of the J-integral approach, and the relation of crack tip processes to toughness. This treatment does not directly deal with crack tip processes. He reviewed the advantages of using the J-integral "resistance curve" (J vs Δa, i.e., toughness vs crack advance). He discussed the *nondimensional* parameter T used by Paris and co-workers, $T=(E/\sigma_0^2)(dJ/da)$, that can be obtained from the resistance curve (E=elastic modulus and T=stress), and the parameter D, which is the amount of crack growth that leads to a doubling of J. For most metallic materials, T is greater than 20 and D is less than 1.5 mm, and D can be defined as $D=J/(dJ/da)$. If D is very much less than R, the radius of the plastic zone at the crack tip, then the nonlinear fracture mechanics (deformation theory plasticity) from which the J integral derives does not apply, and small-scale yielding theory is appropriate. Also for the J-integral approach to apply, the amount of crack growth D must be small with respect to R and to b, the length of uncracked specimen (ligament length). One of the basic mechanistic thrusts of Hutchinson's presentation was that for high toughness the "zone of dominance" of the plastic deformation field around the crack tip must substantially exceed the amount of crack tip advance. If this is so, unstable crack growth will not be obtained.

Another fracture toughness parameter, $G\Delta$, defined as $\Delta W/\Delta a$, that is the increment of energy ΔW released by an increment of crack advance Δa was described by Prof. K.J. Miller (Sheffield Univ., UK). This parameter, unlike others such as K_{Ic} and J_{Ic}, is a crack propagation toughness parameter. Miller's work in this area involves essentially a Griffith energy balance approach, using finite-element method computer calculations of strain field distributions around crack tips during crack propagation. Two key aspects of the crack propagation are identified: 1) events in the "process zone" ahead of the crack, and 2) elastic release events "behind" the advancing tip, which tend to close the crack. Of course, the crack doesn't close completely, it merely tends to slow down as its opening angle decreases. Miller attempted to show that initiation parameters such as K, cracking opening displacement (COD), and J are not suitable for crack growth, and examined the applicability of the parameter $G\Delta$ in various biaxial stress states.

In more experimentally-oriented work, M.F. Cowling (Glasgow Univ., UK) presented results clearly revealing that the J-integral method (or any other method based on a single intensity measure at the crack tip such as COD) must somehow take into account the significant triaxial constraint differences arising from inherently different notch configurations. This appears to be one of the main issues currently holding up the development of engineering fracture mechanics. J.F. Knott (Cambridge Univ., UK) summarized the work of his group over the last few years which has been directly concerned with the micromechanics of metal fracture, particularly the relationship between toughness and microstructure in steels. He discussed the importance of such features as grain boundaries (and the influence of grain size), void initiation at carbides, etc. One point of interest to more macroscopic "mechanikers" noted was a transition of the predominant fracture mechanism from void growth and coalescence in ductile metals with a low ratio of yield stress to Young's modulus, to shear instability linking voids for higher values of the ratio.

In the area of ceramics, Prof. P.L. Pratt (Imperial College of Science and Technology, Univ. of London, UK) and N. Claussen (Max-Planck-Institut für Metallforschung, Stuttgart, FRG) discussed micromechanical toughening mechanisms. Nonlinearity in these materials is confined to an extremely small zone at the crack tip, and consequently LEFM is adequate for macroscopic analysis of cracked configurations. Pratt summarized the features of ceramics that lead to their low toughness, including pores, inclusions, grain boundary phases, grain decohesion, residual stresses due to anisotropy of thermal expansion and (for two-phase ceramics) thermal expansion mismatch. These features augment the inherently high brittleness of ceramics that is due to difficulty in moving dislocations in them. Some evidence suggesting stable subcritical crack growth was reported, possibly due to the opening up of a network of microscopic cracks in advance of the main crack tip. Fracture toughness testing

indicates a dependence on specimen type which may be connected with small amounts of crack growth in the most stable specimen configurations. Claussen showed how the introduction of second phase particles can lead to toughening in ceramics, using supportive data mostly from the Al_2O_3 (matrix)-ZrO_2 (particle) system. Microstructurally the approaches to toughening ceramics seem different from those for metals: such schemes as introducing microcracks, and ductile second-phase particles are favored. However, fundamentally, the aim is the same as for metals, that is, to dissipate energy in ways such that it is not available for main crack extension.

Another group of contributions were concerned with polymers and polymer-based composites of various types. Prof. I.M. Ward (Univ. of Leeds, UK) summarized the status of fracture toughness testing for polymers and discussed some theoretical analyses of the "process zone" near the crack tip. He was able to separate out the strong influence of shear lips and identify the plane strain fracture toughness. He also discussed the perplexing difference in the ordering of toughness of various polymers depending on the use of notched or unnotched specimens in impact tests, a problem that is only partially resolved at the moment. D. Maugis (Centre National de la Recherche Scientifique, Meudon, France) reported some extremely careful comparisons between experiment and theory on the fracture and decohesion of adhesive viscoelastic solid surfaces. Using a Griffith-type approach, he analyzed the growth of cracks travelling along various adhesive interfaces. The resulting predictions were in beautiful agreement with the experimental observations.

Prof. A. Kelly (Univ. of Surrey, Guildford, UK), M.G. Bader (Univ. of Surrey, Guildford, UK), Prof. D. Hull (Univ. of Liverpool, UK), and a number of others discussed fracture modes in a variety of composites. In these materials, the fracture mode can be strongly dependent on the stress state. Kelly discussed constrained failure in composites, Bader considered the micromechanics of strength and failure of short fibre-filled polymers, and Hull reported on mechanisms of fracture in angle-ply composites. Also, C. Bucknall (Cranfield Institute of Technology, UK) described the toughness of rubber-filled materials as a function of rubber content, molecular weight, and crack speed; and Prof. B. Harris (Univ. of Bath, UK) discussed mechanisms of cracking in fibre composites with brittle and ductile matrices, including processes such as fibre rupture, debonding, fibre pull-out, etc. Prof. J.G. Morley (Univ. of Nottingham, UK) gave an analysis of transverse crack growth in brittle matrix fibrous composites, and T. Vinh (Institut Supérieur des Matériaux, St. Ouen, France) analyzed the rupture of multilayered composites. From the various contributions, it would appear that there is a considerable opportunity to design composites with high toughness, although more work is needed to understand the interaction between the various modes of fracture.

In summary, it is clear that there is much concern over which fracture toughness parameter to use, as well as with test methods and specimens. The Colloquium also emphasized micromechanisms of toughening in various materials. The fracture mechanics problems are not trivial in either the theoretical or experimental case. In the microstructural area, we know generally that in all classes of materials we can consider a sort of "energy-absorption zone" around the crack tip and that toughening will be accomplished by introducing features that increase the energy-absorbing density and/or size of this zone. As Ashby pointed out in his introduction to this Colloquium, we still need to establish useful hierarchies of crack-tip energy-absorption mechanisms for metals, ceramics, polymers, and composites. This would lead toward development of a more physical feel for toughening on the microscale. The problems are particularly complicated in the case of post-yield cracking processes and in complex materials such as composites. It is evident that considerably more time and effort must be spent before complete understanding and a unifying model is developed for the various classes of materials.
(Jeff Perkins)

MATHEMATICAL SCIENCES

THE NORDIC-BALTIC YEAR IN MATHEMATICAL SCIENCES

In August and September of each year there are a number of regional and international meetings in the mathematical sciences. This year there were quite a few, this account covering two rather large ones held in Oslo and Helsinki. The 11th European Meeting of Statisticians was held in Oslo in mid-August, and the 1978 International Congress of Mathematicians was held in Helsinki later in the month. Unfortunately there was some overlap between the two. First we shall discuss the statistical meeting in Norway and then go on to the rather huge meeting of mathematicians in Finland.

The European Meeting of Statisticians has been convening since the mid-1960s. Until that time there had been European regional meetings of the Institute of Mathematical Statistics which, although international in its charter, is essentially an American organization. The fact that there were over 350 registrants at Oslo attests to the success of these meetings, and that the registrants were very largely European, indicates the interest in statistics and probability now prevalent in Europe. There were participants from practically every country in Europe and a smattering from Israel, Australia, the Asiatic part of Turkey and two from the US.

Invited and contributed papers ran the gamut of topics in statistics and probability. Two topics that would now normally appear in American meetings were not much in evidence: robustness and multivariate data analysis. The latter was represented by a talk on clustering, given in a rather formal sense, and an interesting paper given by R. Sibson (Univ. of Bath, UK) on the Dirichlet tesselation as an aid in data analysis. This development is geared essentially for spatial analysis and not for large multidimensional data bases found in social and behavioral science. Invited papers of interest were presented by A. Hald (Univ. of Copenhagen, Denmark) on the "Statistical Theory of Sampling Inspection by Attributes"; by L. Schmetterer (Univ. of Vienna, Austria) on "From Stochastic Approximation to the Stochastic Theory of Optimization"; by B.W. Silverman (Univ. of Oxford, UK) on "Density Estimation: Are Theoretical Results Useful in Practice?"; by R. Zielinski (Polish Academy of Sciences, Warsaw) on "Stopping Rules for Sequential Estimation"; R.E. Barlow (Univ. of California, Berkeley) on "Multi-state Network Reliability Theory"; and by B. Penkov (Bulgarian Academy of Sciences, Sofia) on "Splines in Statistics."

This was the first international statistics meeting held in Oslo since 1899, when the International Statistical Institute met there. A group photo in the mathematics library at the University of Olso attests to the latter. Our Norwegian hosts informed us through exhibits of the early contributions of Scandinavians to statistical theory and probability theory. Many of these were motivated by risk and general insurance problems. These included contributions by T.N. Thiele (1838-1910), to whom we are indebted for the notion of semi-variants—or cumulants for characterizing probability distributions; J.P. Gram (1850-1916) for work in step-wise regression; C.L. Charlier (1861-1934) for his work in curve fitting; J.W. Lindeberg (1876-1932) for his work on the distribution of sums of independent variables and what has come to be known as the Lindeberg-Levy theorem; to F. Lundberg (1876-1965) for his work on risk theory in insurance; and to A.K. Erlang (1878-1929) for his work in queuing theory stemming from telephone traffic. To this date, the expected number of busy circuits in a telephone system is measured in "Erlangs," a unit of telephone traffic. Erlang also worked on probabilities of a surname becoming extinct, which attracted the work of others later. Of those named above, Gram, Lindeberg, and Lundberg were specifically motivated by work in insurance.

The University of Oslo provided a very pleasant and friendly setting for these meetings, which took place 14-18 August. Naturally there was overlap of sessions, but it was easy to get from one to another. The next European Meeting of Statisticians (the 12th) is scheduled for September 1979 in Varna, Bulgaria.

There were over 3100 registrants for the 1978 International Congress of Mathematicians held in Helsinki, 16-23 August, and some 1000 family members accompanied the participants. There were 19 areas of mathematics for which

speakers were asked to give one-hour or 45-minute addresses. This led to 137 invited speakers, of whom 120 were present to deliver their talks. Of the 17 addresses not given, 15 were to be presented by mathematicians from the USSR who did not arrive. This seems to be a recurring international meeting problem. Although no nations were mentioned by name, the problem was specifically raised in the closing ceremonies, and the hope expressed that it would be minimized or become nonexistent at future congresses. Countries not permitting their mathematicians to give invited papers at a congress in another country, or the host country not permitting entry were two categories of international behavior not looked upon very favorably by the assembled mathematicians.

Very early in the program of the Congress, Field Medalists are announced. These medals are presented to mathematicians under the age of 40 who are singled out for their contributions to the advancement of the research. At least two are named, and this year four received this special honor. They are: Pierre Deligne (Belgium) of the Institut des Hautes Etudes Scientifiques in Paris, a specialist in algebraic geometry who received his medal for work toward the proof of the Riemann hypothesis, one of the most difficult problems in contemporary mathematics. The hypothesis attempts to predict the number and positions of zeros of the zeta function. Another winner was G.A. Margulis of Moscow, who was honored for his work on discrete subgroups of Lie groups in the mathematical subject of topology. Two Americans were also winners. They are Daniel Quillen of the Massachusetts Institute of Technology and Charles Pfefferman of Princeton Univ. Pfefferman's field is classical analysis. He was strongly praised for his work on dual-space relationships. Quillen, who is in algebraic topology, was mentioned for his work on higher algebraic K theory, a subject he initiated in the early 1950s. The Field Medals carry with them a cash award in the amount of 1500 Canadian dollars. They began at the conference held in Oslo in 1936 and are named after Prof. Field of Canada who suggested the use of surplus funds from past meetings for this purpose. Except in 1968, Americans have always won half of the medals. The mathematical congresses themselves began in 1897 in Zurich, the second was held in Paris in 1900 and every four years thereafter in another country except for 1916, because of WWI, and 1942 and 1946 because of WWII.

The large sessions were held in the Finlandia Hall, a magnificent setting with most comfortable seating. A piano recital by Andre Gavrilov held for the mathematicians also took place here. Other sessions were held in buildings of the University of Helsinki.

The Finns are to be complimented for the manner in which they organized such a large meeting. There is always concern that a meeting of over 3,000 scientists will be impeded by its size. Many of the participants thought this was not so in Helsinki, except for a rain-drenching picnic on Seurasaari Island one Saturday afternoon. All the social activities seemed to go very well and it would not be fair to blame the weather on the Finns. The next Congress in 1982 is scheduled for Warsaw. Professor Urbanik of the University of Wroclaw invited one and all to that upcoming meeting at the closing ceremonies in Helsinki. (Herbert Solomon)

PHYSICAL SCIENCES

OPTICAL SPECTROSCOPY ILLUMINATES SEMICONDUCTORS

The use of optics in the study of semiconductors is widespread. Absorption measurements have been used for determining trap depths and band edges, semiconductor luminescence has developed into lasers, and infrared cyclotron resonance has been used to obtain information about the electronic band structure of many semiconductor materials. However, in recent years the use of very high-resolution spectroscopy to examine both the luminescence emission of semiconductors and also the excitation of that emission has made it possible to obtain even more detailed information about the nature of donors and acceptors. An approach to the study of donors and acceptors by use of optical spectra has many advantages. It is nondestructive and does not require electrical contacts. Small samples can be used and they need not be of a regu-

lar shape. Measurements can be made at a single low temperature, and one measurement gives information both on donors and acceptors.

Optical studies seem to be especially appropriate to the II-VI compounds that are made of Zn or Cd and reacted with S, Se, or Te. These relatively large band gap materials are not presently part of the microelectronics revolution, but they have applications of their own. For example, ZnS is one of the most common cathode-ray tube phosphors. For the most part these II-VI materials can be made n-type by doping but cannot be made p-type. ZnTe is the exception; it can be made p-type but has not been made n-type. The absence of p-type doping in most of the II-VI materials has often been attributed to automatic compensation by native defects such as anion vacancies or cation interstitials. There is little direct proof of the presence of such native defects in sufficient concentration to produce compensation, however. Still, the general inability to produce both n- and p-type materials and the argument that this is related to the properties of defects introduced thermodynamically into the material when it is grown tends to discourage work on semiconductor devices made of these materials.

Dr. P.J. Dean (RSRE, Great Malvern, England) has recently studied ZnTe with great care using improved optical methods. Several factors combine to make his study a very informative one. The material itself is highly refined so that inadvertent impurities are probably at the 10^{15} cm^{-3} concentration or lower. Measurements can be made at temperatures down to 1.6 K, and magnetic fields are available for looking at the Zeeman structure of lines. Finally, very high-resolution emission spectroscopy is matched by the use of an equally high-resolution, tunable dye laser source for exciting the material. [In this work the dye laser measurements were made in cooperation with Dr. H. Venghaus (Max-Planck-Institut, Stuttgart, FRG)]. In ZnTe the edge luminescence and excitation spectra appear at about 2.3 to 2.4 eV; the optical resolution is such that lines separated by 1 meV are very clearly seen both in emission and excitation of luminescence. Dean has studied the shallow donors and acceptors in ZnTe that occur within 0.2 eV of the band edges and which control the electrical conductivity of the material at room temperature.

Donors and acceptors can be recognized through a variety of types of optical spectra. Excitons can be bound to them with a binding energy characteristic of the dopant. If the concentration of dopant is kept below 10^{16} cm^{-3}, this type of spectrum yields very sharp low-temperature lines because they have no broadening resulting from the kinetic energy of a free particle. Another type of spectrum in ZnTe arises from the recombination of a free hole at a neutral acceptor called a free-bound transition. These lines are broader than those of the bound excitons because of the kinetic energy of the free hole. Finally, there are electron-hole recombinations between distant donor and acceptor pairs. These appear to be broad bands because the energy of recombination varies with the pair separation which is not a fixed quantity. The energy of emission from donor-acceptor pairs also varies with the trap depth of the donors and acceptors, and doping experiments may allow identification of these traps. In direct band gap materials like ZnTe the donor traps are very shallow, which makes donor identification difficult by optical means since all donor levels are very close together in energy.

The luminescence and excitation spectra are moderately complex even in the purest of the ZnTe materials. Some of the lines occur as parts of a series; in one such series of lines seven excited states have been found for a single activator. In other cases there are replications of series of lines separated by energies corresponding to longitudinal or transverse lattice vibrations. As with any complex spectroscopy, the unravelling of the data involves considerable skill.

Dean has made a detailed analysis and interpretation of these ZnTe spectra. His most surprising conclusion is that there is no evidence in the optical spectra for zinc vacancies. He is quite certain that a particular acceptor level, previously attributed to a zinc vacancy, cannot arise from such an atomic center. It is not clear at the moment whether this conclusion can be extended to other II-VI materials. In ZnTe, however, neutralization of donors or acceptors by thermodynamically introduced compensation centers probably does not occur. The evidence instead is that defects are associated with isolated Li, P, As, Ag, Au, Cu, and, perhaps,

other atoms. This may stimulate a renewed interest in trying to produce both n- and p-type samples in this material by normal doping techniques.

The II-VI materials still present mysteries. For instance, acceptors in ZnSe are much deeper than in ZnTe because they are associated with a Jahn Teller distortion; there seems to be no simple explanation for the different behavior of these otherwise very similar materials. While the use of high-resolution optical techniques—made possible in part by the development of tunable dye lasers—has certainly helped greatly in extending our knowledge of the difficult II-VI semiconductors, there is obviously still a very great deal to learn both about phenomena in these semiconductors and of ways of controlling them.
(Clifford C. Klick)

WHAT DO ELASTICITY, TROMBONES, AND CAVITIES HAVE IN COMMON?

The answer is nonlinear acoustics, a topic discussed during the 8th International Symposium on Nonlinear Acoustics, held in Paris 3-6 July 1978. Perhaps the most striking aspect of this and previous symposia held in the last few years has been the seemingly unrelated choice of topics selected for discussion—and yet, one single feature has been common to these topics: nonlinearities in the propagation of mechanical vibrations.

The diversity of disciplines represented at the Paris meeting was greater than had been the case in past symposia, at the same time a good deal of convergence toward the common goal was evident: excellent review papers, contributed papers, and poster sessions pointed out the fact that nonlinearities play an ever increasing role. The Symposium was a grand report on the status of nonlinear effects in and relating to the many branches of acoustics and mechanical vibrations. The scope of discussions certainly went far beyond the topics considered during the first symposium of this type where scarcely more than underwater nonlinear acoustics was considered.

The opening session of the Symposium was a memorial to the nonlinear acoustics work of the late R.V. Khokhlov, who had been rector of Lomonosov State University in Moscow until his tragic death last year. The memorial lecture was to be delivered by Prof. V.A. Krasilnikov (Moscow Univ.). Unfortunately, the speaker was unable to attend and Dr. D.T. Blackstock (Univ. of Texas at Austin) hurriedly prepared a substitute paper on Khokhlov's work. As it turned out, Dr. K.A. Naugolnikh (Academy of Science, Moscow) did arrive from Moscow with Krasilnikov's slides, and the opening session was held after all at the scheduled time, with Blackstock and Naugolnikh filling in for Krasilnikov. Both speakers mentioned Khokhlov's contributions to the field, particularly his earlier work in nonlinear optics that evolved into theories of propagation of acoustic waves in nonlinear media. The speakers discussed Khokhlov's mathematical models by which many complicated equations in nonlinear acoustics can be attacked, leading to workable solutions to various problems such as parametric arrays, waves in relaxing media and other optics of current importance.

The technical sessions began immediately after the conclusion of the opening lectures. Eight sessions were held: general acoustics, parametric arrays, solid state, acousto-optics, liquid state and liquid crystals, surface waves, cavitation, and aeroacoustics and large amplitude vibrations. In order to avoid parallel sessions only about one third of the nearly 100 accepted papers were scheduled for oral presentation with the majority appearing in poster sessions.

The first session was devoted primarily to theory on which much of the later contributions was based. Professor J. Bosquet (Belgium) lectured on periodic functions and nonlinear problems. Prof. D.G. Crighton (Leeds Univ., UK) discussed various choices of model equations of nonlinear acoustics, and Profs. A.H. Nayfeh (Virginia Polytechnic Institute, Blacksburg, VA) and J.H. Ginsberg (Purdue Univ., Lafayette, IN) addressed related mathematical problems. Some extended arguments ensued in which speakers and others tried to impress on each other which mathematical approach offers the best advantages.

Less controversial but equally interesting were the remaining sessions which ranged from strictly mathematical descriptions to discussions of actual acoustic devices of the best engineering quality. In short, papers were presented

that one would expect to hear at meetings for pure mathematicians, and papers that could easily be part of a conference for applied engineers. An example of the diversity of the contributions: a presentation by T.G. Muir and M. Vestrheim (Applied Research Laboratories, Univ. of Texas at Austin) on the use of parametric arrays in atmospheric research and pollution monitoring was followed by one by P.J. Westervelt (Brown Univ., Providence, RI) on nonlinear sound generation by hadron showers into the ocean—and an extensive review of nonlinear electroacoustics of dielectric, piezoelectric, and pyroelectric crystals, presented by D.F. Nelson (Bell Laboratories). The finale of this planned mix of papers was a contribution by S.J. Elliot (Univ. of Surrey, Guildford, UK) on nonlinearities and harmonic generation in the mouthpiece of wind instruments.

Many good contributions were displayed during poster sessions which were arranged to bracket lunch. Lunch lasted close to two hours and was served in the nearby School of Chemistry, the site long associated with the names of Langevin and Curie. These working lunches and a reception the evening before the opening session were the only scheduled social affairs. The meeting was well attended; this, according to the general chairman, Andre Zarembowitch of the Univ. of Paris, was at least partly due to the fact that there were no parallel sessions to chose from and that Paris did not escape the cold and rainy European summer. (Walter G. Mayer, Georgetown Univ., Washington, DC)

NICE E-O RESEARCH IN NICE

Professor Daniel B. Ostrowsky is one of a handful of Americans who have managed to obtain a permanent professorial position in a French university. He is working in the Laboratoire d'Electro-optique at the University of Nice. This Laboratory is one of four conducting physics research at the University. All are associated with the Centre National de la Recherche Scientifique (CNRS).

Ostrowsky came to the University from the Laboratoire Central de Recherche (CRL) of Thomson-CSF in Orsay, France in 1976 where he had worked since 1970 on integrated optics. There are two other professors in the Laboratory: F. Gires, who is working on the optics of semiconductors and the Raman effect in optical fibers, and J. Richard, who is working on optical modulation spectroscopy.

Ostrowsky showed me around the laboratories and introduced me to the other research people. While at CRL he, together with other experimenters, developed a fast electrically switched optical directional coupler referred to as Cobra (commutateur optique binaire rapide). Their results were published recently [*Appl. Phys. Letters* 27, 289-291 (1975)]. The switch consists of two parallel, closely-spaced waveguides formed by diffusing titanium into a crystal of $LiNbO_3$. A metal electrode is deposited over each waveguide. When the two waveguides have identical propagation constants, a signal propagating in one guide will be transferred to the other by evanescent waves after a characteristic distance that amounts to about 1 mm for the situation studied. When a 6-V potential difference is applied to the electrodes, the indices of refraction of the guides are made different by the electro-optic effect and the signal does not switch but stays in the first guide. When a signal is introduced into the entrance of guide 1, what one observes at a distance beyond the characteristic length, is a signal emerging from guide 2 when no potential is applied; but the signal appears in guide 1 when the potential is applied. This switch was later improved in 1977 by using a single, two-mode waveguide with two merging input and output single-mode guides [*Appl. Phys. Letters* 31, 266-267 (1977)]. Application of a potential across the two-mode guide causes a mode transfer to occur hence the signal can be switched to either of the output guides.

Recently Ostrowsky has become interested in a new topic whose potential for future applications cannot be assessed yet, but that could lead to a new family of optical/superconductor devices. He has produced Josephson junction behavior in a thin strip of superconducting lead at 5.1 K by using a guided optical wave in a guide underneath and at right angles to the strip. The evanescent portion of the optical wave produces localized excitation of electrons in the region of crossover resulting in a so-called superconducting "weak link" or region of weak supercon-

ductivity. Such a weakened region acts like a Josephson junction. Previously such weak links had to be formed by electron injection or illumination by incoherent light.

Ostrowsky feels that these junctions, in conjunction with optical integrated circuits such as guides, switches, etc., could be used in computers or controllable ir-detector arrays.

Pierre and Christine Bezot, a husband and wife team, are working with Ostrowsky on an interesting scattering problem. They are doing a laser scattering experiment on supercooled liquids such as benzene. The technique is light beating spectroscopy whereby the scattered light is beat with that from a local oscillator. They expect to gain information on orientation and movement of molecules.

The group led by Gires is working on some interesting problems based on the interaction of guided optical waves and free carriers in GaAs layers. They have developed a novel method for measuring depth penetration of photopairs, and collision frequency and relaxation time of free carriers. The ir waveguide is made from a thin weakly-doped epitaxial GaAs layer on a heavily-doped GaAs substrate. A Q-switched ruby-laser pulse incident on the film produces electron-hole pairs near the film surface. An ir-wave propagating through the film is perturbed by the carriers, and a measurement of the change in output intensity as a function of time is made from which the free carrier parameters are determined.

Another technique related to the above has been used to determine the two-photon absorption coefficient in GaAs films at a wavelength of 1.06-μm. In this method a long wavelength, 10.6-μm probe beam from a cw CO_2 laser, is propagated in the film. Simultaneously, a 1.06-μm beam from a pulsed Nd-YAG laser is directed at the film perpendicular to the film plane. The 1.06-μm wavelength is too long to produce free carriers since the photon energy is less than the bandgap energy; however, two photons acting simultaneously have an energy greater than the bandgap energy and can produce free carriers. A single two-photon absorption event produces an electron-hole pair which in turn increases the absorption of the material for the 10.6-μm probe beam. The number of photopairs produced is linearly related to the change in absorption coefficient for the probe beam. The two-photon absorption coefficient can then be determined from basic theory using measurements of the change in probe beam-output intensity and the 1.06-μm beam-input intensity as a function of time. Gires and colleagues obtained a value of 0.06 cm^{-1}/MW which is in good agreement with values determined by other workers in bulk GaAs.

Gires is also interested in the entirely different topic of stimulated Raman effect in optical fibers. He excites a fiber 10-50 m in length with 0.53-μm radiation and observes both stimulated Stokes and anti-Stokes Raman-shifted radiation emerging from the opposite end. He has also produced stimulated anti-Stokes Raman radiation with ir excitation at 1.06-μm. This is a nonlinear effect that depends on the product of the excitation intensity and the fiber length.

Gires sees a potential use for fibers using the stimulated Raman effect as tunable sources in the visible or ir. Liquid-core fibers are more efficient for this purpose than those with solid cores.

The work going on at the Laboratoire d'Electro-optique is a mixture of good fundamental research some of which is speculative. In particular it will be interesting to see how Ostrowsky's efforts on optically-induced Josephson junctions progress in the next few years. (Vern N. Smiley)

PLAIN FACTS ABOUT PLANAR LASERS IN FLORENCE

Dr. Ricardo Pratesi is a Group Leader in charge of the Laboratorio di Elettronica Quantistica (LEQ) del Consiglio Nazionale delle Richerche (CNR) in Florence, Italy. This Laboratory has a professional staff of about 15 scientists and, as the name implies, specializes in laser research. In 1970 the LEQ split off from another CNR institute called Istituto di Ricerca sulle Onde Elettromagnetiche (IROE) that is also in Florence. The IROE is under the direction of Dr. Giuliano Toraldo di Francia who has trained a large number of Italian optical scientists. Recent

work at the LEQ is in four areas: Laser sources, laser applications, laser physics, and physics of radiation-matter interaction.

Organic dye solutions used in lasers have very high absorption coefficients, which means that the concentrations and/or the cell diameter must be small so that optical pumping radiation can penetrate to the core of the liquid. For example, Rhodamine 6G dissolved in alcohol has an absorption coefficient of 121 cm^{-1} at the peak absorption for a 10^{-3} M/liter concentration.

Pratesi and his colleagues have attacked this problem by developing planar dye cells having small dimensions in the direction of incidence of the pumping radiation and larger dimensions in the lateral direction. They found that with a cell thickness of 0.4 mm the operating dye concentration could be as high as 10^{-3} M/liter or 4×10^{-3} M/liter for 100-μm thick cells. Planar dye cells were constructed of two glass slabs, 4 × 20 × 80 mm sealed together with spacers and tilted end windows. Optical pumping was achieved with two U-shaped flashlamps closely coupled to the cell. The dye was circulated slowly through the cell.

The gain is so high in these cells that most of the stored energy can be extracted in one round trip; therefore a resonant cavity is not needed, and the output spectrum is free of mode structure which ensures good frequency and intensity stability. A double-pass configuration, using a single dispersive element such as a grating, allows the device to operate at a few tens of mJ in a narrow line width of a few GHz.

Pratesi's group developed a simple, reliable version of the planar dye laser for use by opthamologists for retinal coagulation. They believe it should compete with other laser devices for the same purpose.

A recent improvement in the planar laser has been reported [D. Pucci, U. Vanni and R. Pratesi, *Nuovo Cimento* 42, 71-76 (1977)]. In place of a planar geometry, a slightly curved slab-cell was used. The curvature produces a focusing effect that compensates for divergence in the laser medium which is a result of thermal effects from the nonuniform lateral illumination of the cell by the pumping light.

Several experimenters have attempted to increase the efficiency of conventional dye lasers by using a mixture of dyes one of which has an optimum spectrum for absorbing flashlamp pump energy and a fluorescence spectrum which coincides with the absorption spectrum of the lasing dye. Dr. P. Burlamacchi (LEQ) collaborated recently with Dr. D. Cutter of Istituto Nazionale di Ottica (INO), also in Florence, on an experimental study of a mixture of Rhodamine 6G and Coumarin 6.

There are two approaches to this problem: One is to physically separate the two dyes by placing the energy transfer dye in the flashlamp cooling jacket and the lasing dye in the laser cell; the other is to mix the two dyes in the laser cell. They found that the first method did not produce an increase in laser energy regardless of the dye concentration, while the second method did produce higher output. These results are thought to be caused by lower scattering losses in the mixture and more efficient energy transfer through a non-radiative dipole—dipole exchange mechanism in the mixture as opposed to radiative transfer between separated dyes.

Burlamacchi is also collaborating with Professor Dr. Fritz P. Schäfer at the Max-Planck-Institut für Biophysikalische Chemie at Göttingen, FRG, on high average power dye lasers. He expects to reach an average power of 150 W soon.

Pratesi is also concerned with medical applications of lasers. In addition to photocoagulators, mentioned previously, he is interested in bio-stimulation healing with lasers. Although the principle is not understood, results of this technique, reported in Hungary and the US, show that healing of wounds has been achieved with an optical intensity of as little as 10 mW/cm^2. The wavelength is apparently not too relevant as both He-Ne and Ar lasers have been used in this work.

In spite of certain difficulties such as not being able to hire new young scientists and organizational problems within CNR, Pratesi's laboratory is producing very good fundamental and applied laser research. (Vern N. Smiley)

PSYCHOLOGICAL SCIENCES

ON TYPING WITHOUT MUCH TRAINING (CONT.)

Alpha-Dot is a system of typing with three keys, and a previous article (*ESN* 32-4:149) discussed how it is being developed in Israel. What is impressive about Alpha-Dot is that the characters of the Hebrew alphabet can be learned in minutes, and the touch typing of text can occur in as little as an hour; the months of training required for proficiency with the standard typewriter keyboard is unnecessary. Moreover, interference from existing skill on the standard keyboard is absent, which is a problem that has bedeviled attempts to revise the standard keyboard.

Alpha-Dot requires each character to be entered by two strokes, with each stroke consisting of 1-3 keys pressed down simultaneously; the coding is both parallel and serial. Spatial imagery is the psychological basis of the coding, where the typist visualizes the shape of the letter and then represents the spatial configuration in the two strokes of the keys. This encoding works for Hebrew, but it is far less successful for the Latin alphabet. D. Gopher (Faculty of Industrial & Management Engineering, The Technion, Haifa), the engineering psychologist who is leading the research on Alpha-Dot in Israel, contends that the imaging of "square" Hebrew characters is nicely suited to Alpha-Dot encoding, but that the perceptually complex Latin alphabet is not.

The scene now shifts to London, and center stage is C. Endfield, a movie producer ("Zulu"). Without influence from Alpha-Dot, it would seem, Endfield invented the "Endfield Microwriter" which is a typewriter with five keys for the typing of text in the Latin alphabet without much learning. Endfield relies on spatial imagery also, but he does not use the serial encoding of two strokes per character as in Alpha-Dot; a single stroke of 1-5 keys is the input for a character. Apparently the requirement of two strokes for encoding a letter is the reason that Alpha-Dot has been less than fully successful with the Latin alphabet.

The Endfield Microwriter is handheld, portable, and like an oversize hand calculator. A light emitting diode (LED) display with a 12-character capacity has the characters moved to the left as they are typed. Control is by a microprocessor. A rechargeable battery powers the unit. The five basic keys are arranged in a semicircle for the five digits, and there is a sixth functions key that is an extra duty for the thumb. In combination with the five basic keys, the functions key is used to shift from alphabet characters to numerals, backspacing and overwriting a correction, insert, etc. A text of 7-8 typewritten pages is stored in the unit's solid state memory, and the contents of memory can be stored on an audio cassette, which holds about 10 memory loads. Both the Microwriter and the audio cassette interface with a high-speed printer for printout. Carriage returns are taken care of automatically, so the user does not have to worry about ends of lines. However, the operator can use the functions key to set his own length of line if he wishes, as he would do with the heading of a letter.

The spatial imagery for the Microwriter code is sometimes approximate, as might be expected in drawing correspondence between the forms of Latin characters and five keys arranged in a semicircle. The imagery is often with a salient part of a character rather than the whole character. In some cases imagery is not used at all. The letters *e* and *o* are typed with the index finger and the middle finger, respectively, because they are high frequency letters in the English language and so it is natural that they should be typed with the able index finger and middle finger, Endfield said. In some cases the same finger-key combination is used for different characters. The same finger-key combination that types the letter *e* also types the numeral 2 when the functions key has established the numerical mode. While all of this may seem to be a conceptual mix, which could have benefitted from systematic psychological research to test and supplement Endfield's intuition and trial and error, there is no suggestion that the code is poor. Endfield types along at a brisk 45 words per minute, and with 15 minutes of instruction I typed by touch the unforgettable sentence *The tall tan lithe girl ran.*

Endfield has had four Microwriter units and a printer on loan to the Pharmaceutical Division, Department of Health and Social Security (Finsbury Square House, 37 Finsbury Square, London) since February 1978. I called W.G. Thomas, Deputy Chief Pharmacist, who has been one of the Microwriter users, and asked him for his reaction. Thomas did not contain his enthusiasm. "Endfield," he said, "has invented more than he thinks." Thomas learned to use the Microwriter within an hour and within a week he was using it routinely and professionally. Thomas estimates that his typing rate is 40 words per minute. Typing in the pharmaceutical world can suffer from a rather high error rate because of a complex terminology that is difficult for secretaries, and the Microwriter system can bypass the secretary and eliminate the problem. The correction capability of the Microwriter takes care of most errors that the typist makes.

Production of the Microwriter is planned for October 1978 in the UK. Hambro Life Assurance (7 Old Park Lane, London), with whom Endfield has his offices, has a 25% equity in the project. Hambro will supply marketing, accounting, and administrative expertise in addition to capital (*Financial Times*, 13 June 1978). The marketing arrangment will be leasing. Four Microwriters with interface units, four audio cassettes with interface units, and 1 printer, will lease for about $700/month, according to present plans. Training and maintenance are included in the lease.

The success and consequences of Alpha-Dot in Israel and the Endfield Microwriter in the UK will be a good show to watch. The Israelis are heading toward a use of Alpha-Dot in aircraft, where it would be handy for easy input to onboard computers with one hand while flying with the other. Endfield talks about replacing the pen, not the secretary, but it is obvious that bypassing the secretary will be an option. (Jack A. Adams)

SPACE SCIENCES

FROM AIRPLANES TO SATELLITES IN THE NETHERLANDS

In addition to hosting the European Space Research and Technology Centre (ESTEC) for the European Space Agency (ESA), the Netherlands can boast a respectable national space program of its own. This program is a direct outgrowth of a strong and continuing aeronautics activity that had its inception during WWI via War Ministry support of an infant aero-industry. This support led to the development of the famous WWI Fokker aircraft and to a continuing range of aircraft now represented by the F-27 and F-28. The initial vehicle for support of aeronautical research was the Government Service for Aeronautical Research which now bears the name of the National Aerospace Laboratory (NLR) and operates as a nonprofit foundation. Its capital investments and internal research programs are financed through government grants, and additional funding is accomplished through contract research and development. The contract research funding must equal 60% of the total, and the Laboratory can solicit contracts from virtually any source. NLR is headed by a board of directors composed of representatives from the civilian and military sectors of the Government, the aerospace industry, and the airlines. The Laboratory is managed by a General Director and supports two complexes—one in Amsterdam mainly involved in aerospace research, and the other in Noordoospolder that is primarily responsible for space research and technology. The total Laboratory staff consists of about 400 scientists and engineers and 250 technicians and support personnel. About two-thirds of the personnel work in Amsterdam with the remaining staff in Noordoospolder.

The activities of NLR are divided among four Divisions: Fluid Dynamics, Flight, Structures and Materials, and Spaceflight. The majority of programs are carried out on a project team basis with the project leader receiving support from various divisions and a scientific and technical support staff. The Spaceflight Division consists of a basic contingent of 25 members (70% pro-

fessional) and rises to over 50 depending upon the number and size of the various assigned projects. The main objective of this Division, as of NLR as a whole for aerospace, is to provide technical expertise to national industry through research in specialized areas of space technology. Because of the relatively limited size of the Spaceflight Division, its areas of specialization have been directed towards satellite stabilization, attitude control, thermal balance, and user requirements.

In addition to participating in numerous ESA programs, NLR assisted in the Netherlands Astronomical Satellite (ANS) which was launched in 1974 and is currently participating in the Infrared Astronomical satellite (IRAS) program which is a joint Dutch (50%), US (45%), UK (5%) venture. NLR will provide the software development portions of the ground checkout and operations and perform attitude control testing for the IRAS. The software development is of particular importance since the attitude control, telemetry control, sun acquisition, data handling, and decision making will all be under computer control.

NLR is the laboratory arm of what might be considered a parent or headquarters organization known as the Netherlands Agency for Aerospace Programs (NIVR). The NIVR was established in 1946 as a semi-governmental agency for promoting industrial aerospace activity. Its primary missions remain steering, coordinating, and financing the development of aerospace and space programs and products. NIVR is considered a "private foundation" even though it is funded by the government through the Ministry of Economic Affairs. As in the case of the NLR, it is governed by a board of directors consisting of members from several government ministries, the aerospace industry, the airline companies, and institutions for scientific research. NLR has a representative on the board of the NIVR and the NIVR is represented on the NLR board. The private foundation notation comes partially from the nature of the governing board composition and partially from the fact that after the profits of any private aerospace company, supported by the NIVR through contracts, R&D transfer, or technical assistance, reach a certain value, a portion of the excess profits are returned to the NIVR.

In 1970 the scope of the NIVR was extended into the field of space development. This event correlated with the development of the first national satellite, ANS, for which the NIVR became program manager. At this time, the NIVR was also officially given the task of advising and assisting the Dutch Government with regard to participation in ESA programs. To this end NIVR personnel participate on the appropriate ESA boards and committees. The Netherlands contributes 2.91% of the total ESA budget and would be content for an equitable return of ESA contracts if such a return would enable it to keep its space science and technology expertise at the desired level. Unfortunately this has not been the case as NIVR and NLR must compete with other national space agencies such as CNES of France, DFVLR of Germany, and CRA of Italy, which are large enough both to insure the capability of their countries' aerospace industries to become prime contractors for large ESA satellite programs and to sponsor national satellite programs.

It was primarily for this reason that NIVR proposed a second national satellite program to the Government. This is the IRAS satellite that received government-approved funding for a preliminary definition study in March of 1975. The program is basically on schedule with an anticipated launch date of early 1981. The satellite will carry as its payload a 0.6 m-diam. telescope cooled with liquid helium to a temperature of about 10 K. The cooling will provide the high sensitivity required for realistic measurements against low background noise. An array of about 100 detectors will be used to measure the infrared flux in four wavelength bands centered at 10, 20, 50, and 100 microns. The sensitivity of the first three channels will be set by the photon fluctuations in the flux from the zodiacal light. Sources will be located in the sky with a positional accuracy of 0.5 arc minutes. The telescope is designed to investigate the structure of extended sources with angular scales up to 1.0°. The entire sky will be "surveyed" by combining the limited pointing capability of the telescope with the orbital motion of the spacecraft. To ensure confidence in source detection and identification it will be necessary to repeat observations on time scales of seconds, hours, weeks, and months. About 50% of the sky will be covered

within the first few weeks, but the full one-year lifetime of the mission is necessary to complete the experiment. In addition to the prime survey mission, approximately 40% of the time will be available for special observation programs whose main objectives are to improve the classification of sources found in the main survey by low-resolution spectroscopy and extension of the wavelength coverage to longer wavelengths.

The satellite will be placed in a circular, sun-synchronous, twilight orbit at an altitude of 900 km. The inclination will be 99° and the period will be 103 minutes. This orbit was selected as the best compromise between radiation background, contamination by the ambient gas molecules and ions, launch vehicle capabilities, duration of ground contact, and eclipse duration. The total launch mass of the satellite is about 900 kg including 100 kg of liquid helium for cooling the telescope. It is designed for a Delta 2910 launch from the US Western Test Range. Prime power will be provided by two deployable solar panels designed to provide a minimum end-of-life power of 350 W.

The cooperative program will be managed by a joint project executive group of the three participating countries. As to task distribution, the Netherlands will basically act as primer contractor with responsibility for spacecraft design, development, and manufacture. In addition, it will be responsible for design, development, and manufacture of a low-resolution spectrometer (one of the secondary payloads); satellite system design control; flight model integration, test, and launch preparation; ground checkout equipment; mission analysis; and scientific (nonsurvey experiment) data processing. These tasks are being managed under contract by NIVR and the Committee for Geophysics and Space Research of the Royal Academy of Sciences. The US is building the telescope, detectors, and cryogenic system (via the Jet Propulsion Laboratory); providing launch services; and performing data processing of the survey experiment. The UK, through the Science Research Council, is to provide a long wavelength photometer experiment and ground operations.

While the roles of the US and the Netherlands could have readily been reversed in the IRAS program as the Dutch have been eminent astronomers for many years, it is more important for the Netherlands to maintain the expertise they cannot do *vis à vis* participation in ESA—namely the ability to provide prime contract services for a satellite at a price within their budget. The development of the ANS demonstrated Dutch capability to conduct a national satellite program and the IRAS is enabling them to maintain it on an international cooperative basis. (Robert W. Rostron)

NEWS & NOTES

CLOSURE OF THE APPLETON LABORATORY

The Science Research Council (SRC) has announced that their Appleton Laboratory, one of Britain's leading research stations, is to be closed down and its facilities moved to the Rutherford Laboratory (another SRC Lab) some 40 miles away. It is intended that the work at Appleton, concentrating mainly on space research, will be progressively transferred to the Rutherford over the next five years to cause minimum disruption to research programs. Professor Sir Geoffrey Allen, Chairman of the SRC, said the move is being made to allow existing research capabilities to be stretched farther as some facilities are now duplicated in both labs. He further stated that the Council hopes that the names of Appleton and Rutherford will still be used in connection with the new collective laboratory. It is expected that there will be major programs in the radio-communications and space science areas at the new site.

NEW INSTITUTION FOR MECHANICAL ENGINEERING TECHNICIANS

A new independent institution which will cater for Britain's 100,000 technicians in mechanical engineering was launched 5 October 1978. The new body, called the Institution of Technician Engineers in Mechanical Engineering, will be a fully independent learned society and qualifying body for technicians. It is backed by the Institution of Mechanical Engineers, and both institutions will be housed in the same building in Birdcage Walk, London.

NEW LABORATORIES IN FRANCE

The Centre National de la Recherche Scientifique (CNRS) in France has recently established several new laboratories. The Biochemistry Center installed on the campus of the Univ. of Nice is now the home base for three teams headed by Michel Lazdunski (molecular neurobiology), Gérard Ailhaud (cellular biology) and François Cuzin (virology). The gathering together of these different teams should lead to a new take-off in three extremely important fields, i.e., neurochemistry, nutrition, and carcenology.

The CNRS has just created the Oncology and Immuno-Hematology Laboratory as an integral part of its own structure. The new Laboratory is linked to the Univ. of Paris VII. It is composed of three teams which belong to the Institute of Hematology: Professor Jean Dausset's team mainly concentrates on the field of immunogenetics in men and mice, Prof. Maxime Seligmann's team is known for its discovery of the heavy-chain disease which is an interesting model for research on the genetic mechanisms of immunoglobin synthesis. Professor Michel Boiron, who has been appointed Director of the new Laboratory, leads the third team devoted to research on the biology of retroviruses which are oncogenic viruses, especially those of leukemia and sarcoma.

RESEARCH COUNCILS

The Science Research Council (SRC) and the Medical Research Council (MRC) of Britain have recently appointed new members. To the SRC, the four scientists named are Dr. Peter Clarke, Director of the Robert Gordon's Institute of Technology, Aberdeen; Dr. Wilfred Cockcroft, Vice-Chancelor of the New University of Ulster; Dr. Robin Nicholson, Vice-President of the Metals Society; and Prof. John Willmott, Director of the Physics Laboratory at Manchester Univ.

The MRC has appointed Dr. Sydney Brenner, Head of the Cell Biology Division of the MRC Laboratory for Molecular Biology at Cambridge; Prof. Geoffrey Dawes, Director of the Nuffield Institute for Medical Research, Oxford, Prof. Henry Evans, Director of the Council's Clinical and Population Cytogenetics Unit, Edinburgh; Prof. Raymond Hoffenberg, the William Withering Professor of Medicine at Birmingham Univ.; and Prof. William Shaw, Head of Biochemistry at Leicester Univ.

PERSONAL

Prof. J.M. Alexander, formerly Professor of Applied Mechanics at Imperial College of Science and Technology, has taken up his appointment as Head of the Department of Mechanical Engineering at Univ. College, Swansea, Univ. of Wales.

The Gold Medal of the CNRS, one of the highest French scientific awards, has been presented for 1978 to Maurice Allais, an economist and professor at the Paris School of Mining and Research Director of the CNRS, and to Pierre Jacquinot, a physicist and former Director General of CNRS and Director of the Aimé Cotton Laboratory.

Peter Bradshaw, Reader in Fluid Dynamics at Imperial College of Science and Technology, Univ. of London, has been appointed to Professor of Experimental Aerodynamics at IC.

Prof. Paul Grieveson, Professor of Extraction Metallurgy at the Univ. of Strathclyde in Glasgow, has taken up his appointment as Professor of Applied Metallurgy at Imperial College of Science and Technology, Univ. of London.

Prof. Henry P. McKean, Professor of Mathematics at the Courant Institute of Mathematical Science, New York Univ., has been appointed to the George Eastman visiting professorship, Univ. of Oxford from 1979-80.

Dr. M. Stone, Professor of Probability and Statistics at University College, London, has been appointed to the Chair of Statistics there.

OBITUARY

Professor Manne Siegbahn, the Swedish scientist who won the 1924 Nobel Prize for Physics for his work on x-ray spectroscopy, died in Stockholm 26 September at the age of 91. He was Professor of Physics at the Univ. of Lund from 1920-23, moving to the chair of physics at the Univ. of Uppsala in 1924. For some years he had been researching into x-ray spectroscopy, and in 1916 he had discovered a new group of spectral lines, the M-series. Later he developed equipment and techniques that allowed him to determine accurately the wavelengths

of x-rays, and his precision techniques greatly enlarged knowledge of the energy and radiation conditions in the electron shells of the associated atoms. This work earned him the Nobel Prize. In 1927 when the Swedish Royal Academy of Sciences created the Nobel Institute of Physics at Stockholm, it appointed Siegbahn as Director. In the same year, he became Professor Physics at the Univ. of Stockholm.

ONRL REPORTS

R-8-78

AN OVERVIEW OF ELECTRONICS EDUCATION IN POLAND AND ROMANIA by D.K. Cheng

To promote mutual understanding and exchange scientific ideas, the US National Academy of Sciences has established exchange programs with Eastern European countries. This article reports some factual information and personal impressions of the engineering education in general and electronics education in particular after a month-long trip to Poland and Romania.

C-10-78

THIRD INTERNATIONAL CONFERENCE ON RAPIDLY QUENCHED METALS by J. Perkins

The technical content of the Third International Conference on Rapidly Quenched Metals, held 3-7 July 1978 at the University of Sussex, is reviewed. Papers on techniques of rapid quenching, metallic glass formation, crystallization from the amorphous state, applications of metallic glasses, and other subjects covered at the conference are described.

C-11-78

FOURTH INTERNATIONAL BIODETERIORATION SYMPOSIUM BERLIN, WEST GERMANY, 28 AUG-1 SEPT 1978 by E.C. Haderlie

This is a short account of the Fourth International Biodeterioration Symposium discussing briefly the aspects of biodeterioration covered. A complete list of papers presented is included, however, as proceedings are to be published within six months; no papers are discussed.